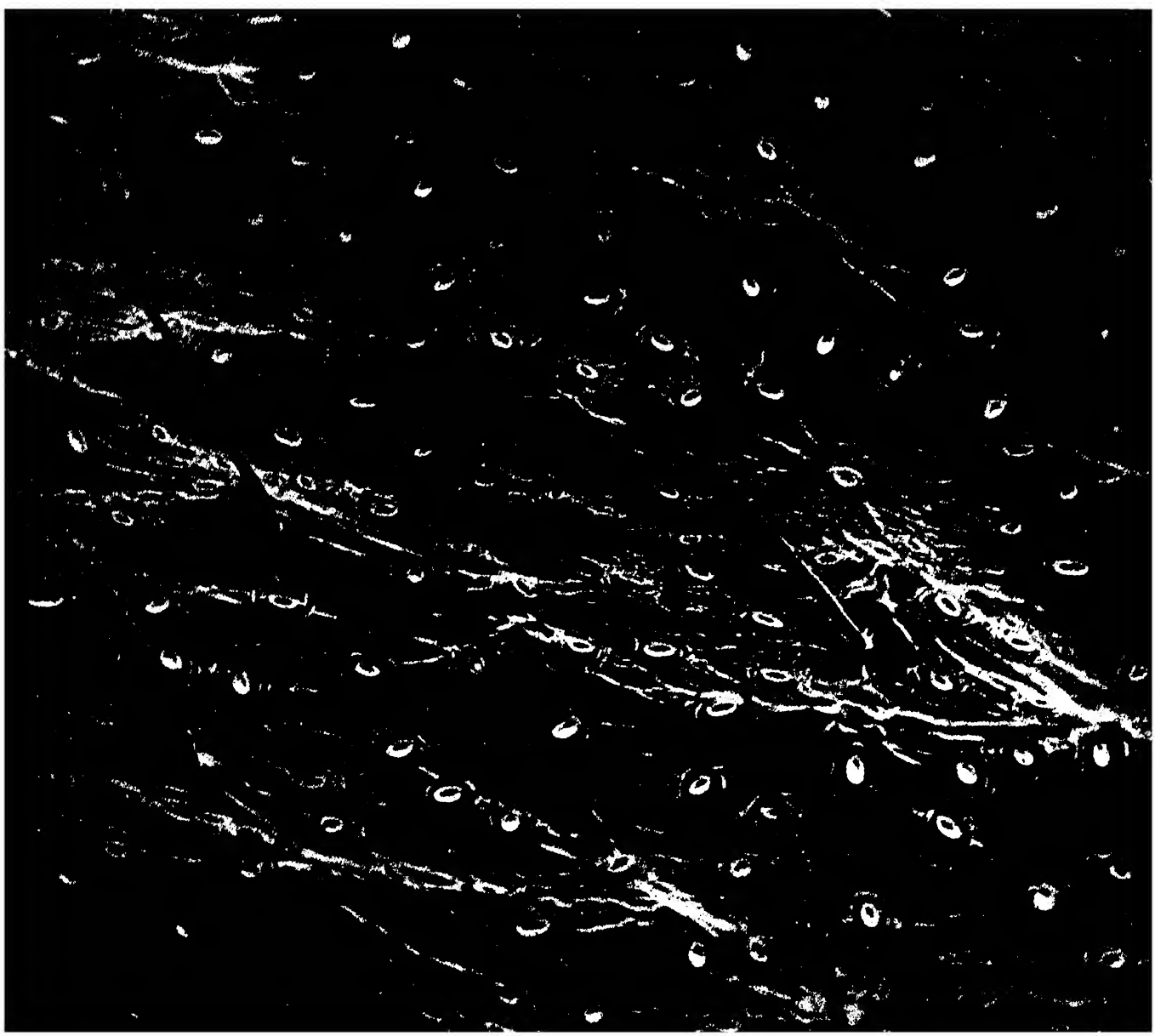
ANNUAL SCIENTIFIC REPORT 1971-72

TEA RESEARCH ASSOCIATION, CALCUTTA



CAN YOU IDENTIFY ? (SEE INSIDE COVER)

OUR COVER

Names of the first five persons who correctly identify this photograph will be published in the next issue of Two and A Bud.

TEA RESEARCH ASSOCIATION

Annual Scientific Report

(1st April 1971 to 31st March 1972

Published by
TOCKLAI EXPERIMENTAL STATION
JORHAT-8, ASSAM, INDIA
1972

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Contents

Director's Report

(1st April 1971 to 31st March, 1972)

ORGANISATION

On the 31st March 1972, the Senior Staff consisted of :-

Directorate :
Director
S. K. Dutta, B.Sc. Hons. (Bom.), B.Sc.(Wales)

Deputy Director
N.K. Jain M.Sc. Ag. (Banaras), Ph.D. (Illinois)

Administrative and Finance Controller
M. K. Choudhuri, B.Com. (Cal.), A.C.A.

Accounts :
Accounts Officer
S. Mazumdar, B.Com. (Cal.), A.C.A.

Maintenance :
Station Engineer
G. B. Singh, A.M.I.S.E.

Medical :
Resident Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Library & Publications :
In-Charge
J. N. Sharma, M.A.

Soils & Meteorology Department :
Soil Scientist
S. K. Dey, B.Sc. (Cal.), Assoc. I.A.R.I.

Senior Scientific Assistants
N. G. Bhattacharyya, B.Sc.
A. K. Sengupta, B.Sc.

Botany Department :
Senior Botanist
D. N. Barua, B.Sc. (Cal.), Ph.D. (Cantab.)

Plant Physiologist
W. Hadfield, B.Sc. Hon. (Liv.)

Plant Breeder
H. P. Bezbaruah, M.Sc., Ph.D. (Gau.)

Senior Scientific Assistants
K. N. Dutta
B. N. Gogoi, B.Sc.

Agriculture Department
Agronomist
F. Rahman, M. Sc. Ag. (Bihar), Ph.D. (I.A.R.I.), New Delhi

Manager, Borbhetta Experimental Estate
H. N. Sarma, B.Sc.

Entomology Department :
Entomologist
B. Banerjee, M.Sc., (Cal.), M.S. (S. Illin.), Ph.D. (London), F.A.Z., F.R.E.S.(London).

Senior Scientific Assistant
N. S. Sengupta, B.Sc.

Mycology Department :
Mycologist
G. Satyanarayana, B.Sc. Hons. (Andhra), Ph.D. (Mad.), F.B.S.

Biochemistry Department :
In-charge
S. Chakraborty, M.Sc., Ph.D. (Cal.)

Tea Tasting Department :
Tea Taster
R. P. Basu

Second Tea Taster
S. Sen, B.Sc.

Third Tea Taster
A. K. Das, B.A.

Engineering Research & Development Department :
Senior Research Engineer
D. N. Barbora, B.Sc. Mining (Banaras). M.Sc. Eng. (London), D.I.C., M.I.Ag.E.

Second Research Engineer
T. C. Barua, B.Sc. Hons.(Gau.), B.Sc. Mech. Eng. (Banaras) M.Sc. Mech.Eng.(Man.)

Senior Assistant
P. Morera

Statistics Department :
Statistician
A. K. Biswas, M.Sc. (Gau.)

Advisory Department, Assam :
Senior Advisory Officer—*Assam*
P. C. Sharma, M.Sc. (Banaras), Ph.D. (London), F.L.S.

Advisory Officers—*South Bank*
T.K. Ghosh, B.Sc. Ag. (Pat.), Ph. D. (Cornell), Assoc. I.A.R.I.

B. C. Barbora, B.Sc.Ag., M.Sc. Agronomy (I.A.R.I.), New Delhi.

Advisory Officer designate—*South Bank*
B. N. Barthakur, B.Sc.Ag., M.Sc. Agronomy (Gau.)

Advisory Officer—*North Bank*
H. Mitra, B.Sc. (Cal.)

Advisory Officer—*Cachar*
J. Chakravartee, M.Sc. Ag. (Gau)

Advisory Department, West Bengal :
Chief Advisory Officer—*West Bengal*
W. J. Grice, M.A., Dip. Ag. (Cantab)

Advisory Officer—*Dooars*
S. Basu, B.Sc. Ag. Hons. (Delhi), Assoc. I.A.R.I

Advisory Officer—*Darjeeling and Terai*
S. K. Sarkar, B.Sc. (Cal.), B.Sc. Ag. (Banaras)

SENIOR STAFF MATTERS

(a) **Appointment :**
Mr. S. Sen joined as Second Tea Taster on 1.4.71.
Mr. A. K. Das joined as Third Tea Taster on 16.6.71.
Mr. B. N. Barthakur joined as Advisory Officer on 19.8.71.
Dr. N. K. Jain joined T.R.A. on 2.5.72 as Deputy Director.

(b) **Retirement :**
Mr. R. Choudhury, Manufacturing Adviser and Tea Taster resigned from service on 31.7.71.

Dr. N. B. Chanda, Officer in-Charge, West Bengal Experimental Station, Mal retired from the Association's service on 31.3.72.

Dr. M. S. Rao, Soil Physicist resigned from the Association's service on 9.6.71.

Dr. R. N. Roy, Second Agronomist resigned from the Association's service on 28.1.72.

TRAINEE

Ten trainees completed the one year course on Tea Culture during the year under report. Besides Member estate employees, there were nominees from Mauritius, Sikkim and Tea Board.

In addition, eight employees from Member estates completed six months training in vegetative propagation and six employees from Member estates completed three months training in the same course.

TOCKLAI CONFERENCE

25th Tocklai Conference was held on the 16th, 17th and 18th November 1971 which was attended by 141 Members and invitees. The Proceedings of the Conference were published seperately.

LECTURE COURSE

The following Lecture Course were held during the year :—

1. **Agricultural Chemicals Course (1971)**
   1st Course from 31st March to 3rd April 1971 --18 Planters attended.

   2nd Course from 5th April to 8th April 1971 --24 Planters attended.

2. **Manufacturing Course**
   1st Course from 26th to 29th April 1971 -- 28 Planters attended.

   2nd Course from 3rd to 6th May 1971 -- 27 Planters attended.

3. **Surveying and Drainage Course (1971)**
   1st Course from 22nd to 26th November 1971 --28 planters attended.

   2nd Course from 29th November to 3rd December 1971--26 Planters attended.

   3rd Course from 6th to 10th December 1971 --22 Planters attended.

   4th Course from 13th to 17th December 1971 21 Planters attended.

VISITORS

Some of the Visitors in addition to local planters are listed below :-

H. K. Jain—Heal, Genetics I.A.R.I., New Delhi.
John P. Devine—McMeekin, London.
B. K. Sen Gupta—S. F. India Ltd, Calcutta.
V. K. Sardana—TEAMA, Calcutta.
M. Lamond—Chairman T.R.A., Calcutta.
Puspalata Das— Member Employment Review Committee, Assam.
D. W. Beal— F.A.O./IBRD Coop : Programme, Rome, Italy.
Mena R. Bustrillos—College, Laguna, Philippines.
K. Letruara—IBRC, Washington U.S.A.
J. A. Clement Inst. Nat. Agro. Paris.
A. K. Das Gupta-Commissioner of Income Tax.Assam.
D. D. Khanvilkar The B.B.T.C., Coimbatore.
Betty Jane Jones American Consulate General, Calcutta.

Shibbanlal Saksena M.P.
S. B. Patil M.P.
V. B. Taradekar M.P.
Ram Ratan Sharma M.P.
N. Tomb Singh M.P.
Hamen Singh M.P.
Mohon Sarnad M.P.
S. K. Mehra—Vice Chairman T.R.A.
M. S. Iyengar -Director, R. R. L., Jorhat.
Carlos Vidalon -World Bank, Washington USA.
Ercel Eppright (Mrs) -do-
Ane Stam -do-
S. Mukerji—Krishi Bhavan, N. Delhi.
Maxwell Mayers S. D. State University, Brookings, USA.
Y. Nayudama Director General C.S.I.R.
R. L. Hards- Chairman London Scientific Comm.
H. Vardhan—Shaw Wallace & Co.
A. Chakravartti—Hindusthan Steel & Co., Ltd.
B. R. Vohra- Chairman, Tea Board.
M. K. Dutta--Director, Tea Development Tea Board.

Advisory Department—Assam

GENERAL

Posting and Transfer

Dr. T. K. Ghosh joined at Tocklai as Advisory Officer, South Bank and Mr. J. Chakravartee took over the charge of the Cachar Advisory Department from the middle of February 1972.

Weather and Crop

In general, Assam produced more crop compared to the previous year and with the improvement in the field management practices, it is expected that this trend will continue during the next few years. In the North Bank of Assam, the crop increases in Borsola, and Tezpur sub-areas were spectacular. In some estates of the Hailakandy, Happy Valley and Longai Sub-areas of Cachar, record crop was harvested although in some other estates, there was reduction in crop outturn due to hail damage in the early part of the season.

Advisory and Extension Services

Visits to Estates :

As in the previous years, the demand for the Advisory visits was on the increase from the Member estates. Specialist officers also paid visits to estates whenever it was possible for them. There was a positive response from the Member estates to follow the general recommendations given to them as far as was possible within their financial and administrative limits. In addition to the general problems, discussions during the advisory visits concentrated around topographical planning, contour drainage and contour planting, use of herbicides, bringing up of young tea, foliar application of trace elements, potash nutrition, vegetative propagation and rejuvenation of mature teas. It is hoped that further discussions would continue on these points with the Member estates to implement these field management practice into their programme of work.

District-wise advisory visits paid were as follows :

District	Total no. of visits	No. of estates visited	No. of Member estates in the district
South Bank	210	132	245
North Bank	202	75	86
Cachar	85	31	36
Total	497	238	367

Field Management Practices

(a) **Land plannting and drainage :**

The Surveying and Drainage Course had a direct impact on the planters who are now becoming much more conscious about the need for efficient land planning and drainage systems. Besides improvement in the existing drainage, a number of estates showed keen interest on topographical planting of extension and replanted areas. Regular advice on these aspects of field management was given to the Member estates and necessary help was rendered in implementation of these programmes wherever possible. In many cases, where the drainage was not adequate due to lack of proper outfall, emphasis was given to find out alternative suitable outlets by level survey. Wherever these were done, the tea started showing signs of improvement. The importance of proper size, shape and gradient of the main and sub-main drains for efficient discharge of the drainage water, however, was not fully realised by the majority of estates. It was stressed on many occasions that a good drainage system inside tea sections might well be nullified if the outlet remained poor or main or sub-main drains were not adequate in size. In the North Bank and Cachar, the old system of deepening the old subsidiary drains runn-

ing down the slopes was discouraged and modifications in the alignment, wherever necessary, were suggested. These suggestions met with good success in many Sub-areas. The advices on level survey and contour drains were followed where funds and facilities were available but in many cases, due to the time limit fixed by the Tea Board under the Replanting Scheme, correct drainage systems could not be laid out. In Cachar, where drainage is one of the most serious problems, most estates obtained good results by isolating the flats by providing deep perimeter drains at the foot of the 'teelas'. A demonstration on surveying and drainage was held during the year in one of the Member estates which was well attended by the Managers and Assistant Managers. A full discussion on the need of contour and level survey and provision of contour drains was held at the demonstration site. Cachar estates were now convinced of the need to provide contour or graded contour drains on teela slopes and this had now become a regular practice. Master row planting had not yet been fully accepted in Cachar as well as in the other parts of Assam.

Difficulties continued to be experienced by a number of estates whose main drains still ran through land not belonging to them and were often bunded for fishing or paddy cultivation by labourers or outsiders. This caused backflow of drainage water and reduced the efficiency of the good drainage system inside the estate.

(b) **Pruning cycle:**

In general, most of the large estates followed a three-year pruning cycle of Prune – Deep skiff – Medium skiff, but many other estates had been trying out a four-year cycle with lighter forms of skiff or unprune, or a three-year pruning cycle with level-off skiff or unprune in the third year. This tendency of a longer pruning cycle was relatively more marked in the North Bank of Assam and Cachar although some of the estates still continued to remain on a two-year cycle in the North Bank and Assam Valley. A few estates in the Nowgong Sub area continued to follow a two-year pruning cycle of Prune–Deep skiff although a number of estates had extended their pruning cycle with one or two years of unprune in the cycle. Stepped-up plucking in the pruned year, followed by unprune gave good results in a number of estates in the Assam Valley. A few estates in the Assam Valley still continued to prune the bushes annually for fear of losing quality!

Rejuvenation pruning was introduced in the North Bank and Cachar during the last few years. Initially, most estates were hesitant to do this pruning for fear of high mortality but as a result of regular advice on proper method and time of the operation it had proved to be a success with many and the correctness of the step had been increasingly accepted. In the South Bank, rejuvenation pruning had just taken a start except for one group of estates in Doom Dooma sub-area where this step was being tried during the last three to four years.

The Advisory Officers remained alert during their visits to the Member estates and wherever the standard of field work was not satisfactory, advice was given and the proper methods were demonstrated on the spot.

(c) **Shade :**

There was a growing feeling among some estates in Upper Assam that shade should be reduced drastically. While advice on judicious reduction in the heavily shaded sections was given, caution was expressed by the Advisory Officers against any drastic reduction until complete evidence to support this view was obtained. It was also pointed out that the amount of shade requirement will vary with the kind of tea.

In Cachar, there was some improvement in the shade status. The extreme variation in shade density in the district still remained to be attended to, although efforts have been made to induce the estates to plant up *Indigofera teysmanii* for providing quick shade until the permanent shade trees took over. Wherever it was heavy, judicious removal of the shade trees like *Albizzia procera, Albizzia moluccana,* cankered *Albizzia chinensis* and *Cassia siamea* was suggested and was followed by many. After a long presuasion, many estates in the North Bank started thinning out the heavily shaded teas. *Albizzia*

procera and *Albizzia chinensis* were the first to be taken out from these areas. The estates having no problem with *Albizzia chinensis* were, however, advised to continue with this species.

In general, *Albizzia odoratissima*, *Albizzia lebbek*, *Derris robusta*, continued to be the common permanent shade trees. *Acacia lenticularis* had been tried in some estates with good results. *Dalbergia sericea* was also found to be successful in a number of estates and its use as one of the permanent species was encouraged.

The Advisory Officers continued advising Member estates to establish temporary shade of *Indigofera teysmanii* at closer spacing of 1.5 m - 2.5 m in extensions planting and replanted areas prior to planting out tea, in preference to green cropping. This item of the field management practice was gradually gaining ground among the estates in all areas.

The need for making proper planting pits, manuring at the time and subsequent to planting out shade trees and after care including spraying against pests and diseases were stressed during the visits to estates.

(d) **Cultivation and Weed Control :**

It was heartening to see that chemical weed control was accepted by more and more estates. They have realised that this was not only economical in the long run but also allowed the labour to be utilised for other productive work during the growing season. The common herbicides used were Paraquat (Gramoxone), 2,4-D, Dalapon, Simazine and Diuron (Karmex) singly or in various combinations. A mixture of 2,4-D @ 2 kg (a.i) plus 2,4,5-T @ 1 kg (a.i) per hectare was recommended for killing hardy creepers inside tea by careful spot spraying, and shrubs and hardy weeds in non-tea areas.

Use of suitable herbicides in young and newly planted tea areas proved successful with those who could use these carefully. In general, manual cultivation was discouraged except where filling up of the depressions was necessary and where paucity of funds or non-availability of the chemicals stood in the way of chemical control. During the advisory visits, the correct time and method of application of these chemicals and spot spraying were stressed.

(e) **Manuring :**

Potash manuring continued to be the talk of the year and in general good results were obtained by blanket application of potash at 80--120 kg/ha wherever the available potash content was below optimum. Not only the need for potash application, but also its beneficial effects in terms of crop yield and general improvement in the health of the bushes were realised by the estate managers. This was abundantly clear from the willingness of the managers to apply potash. It is expected that the use of potash will progressively increase every year. Unfortunately, many estates could not apply potassic fertilisers due to their non-availability. In spite of our advocating potash application, some estates in the North Bank, did not go for remedial dressings at high rates.

Nitrogen had been generously applied during the year and in the South Bank, it was increased to about 130 kg/ha in many estates. Urea was used in place of sulphate of ammonia to a considerable extent.

Encouraging results in terms of crop yield were obtained from application of trace elements viz. Zinc, Magnesium, Manganese and Boron. Some estates had already gone in for field trials this year under commercial conditions.

Where phosphatic fertilisers were used, triple superphosphate, di and mono-ammonium phosphates were recommended in preference to single superphosphate.

(f) **Plucking :**

The fact that a good plucking standards is of prime importance in maintaining quality, was gradually realised by most estates.

The improving trend in the standard of plucking in general was an achievement of the advisory services offered by this department although much was yet to be improved in the lighter skiffed and unpruned teas in some estates. It was particularly pointed out that large quantities of leaf could be lost due to inefficient plucking.

(g) **Mulching :**

Wherever adequate mulching could be done, the young tea benefited to a large extent. In most estates, however, suitable mulching materials were not available to cover large areas of extension or replanted teas. Advice on growing suitable crops for mulching like Guatemala and Pusa Giant Hybrid Napier in waste lands, *hoola* edges etc. was followed by many. Growing of these grasses inside the young tea areas was discouraged.

(h) **Low tipping method of bringing up young tea :**

The fast rate at which the low tipping method of bringing up young tea with and without pegging was followed throughout Assam, indicated the success and its acceptance by Member estates. Apart from clones, some estats tried this system with seed plants as well, and wherever it was followed properly, good results were obtained. The Advisory Officers however, most aptly pointed out that the success of this system lay in efficient weed control, maintaining the health of the bushes including adequate manuring, proper plucking and raising the table only when it becomes full.

In the North Bank, this method did not produce encouraging results in replanted tea where the above prerequisites were not properly adhered to. In such cases, advice was given to raise the table and improve the general health of the bushes.

There was a growing feeling that higher rates of manuring than was normally followed in the conventional method of bringing up young tea would be beneficial in this new system. Encouraging results were obtained by estates who used 10 g Y.T.D. manure mixture at six to eight weeks interval three to four times in the first year after planting as suggested by the Advisory Officers after careful observation of the general health and growth of the plants.

(i) **Other field management practices :**

The art of cleft grafting was mastered by more and more estates during the year and this was accepted as an established method for quick multiplication of clonal material by many estates and for the conversion of old seed baris to clonal seed baris by some. The estates were advised to select good, healthy and vigorous stocks for better success.

In general, vegetative propagation was a success with most estates although in some cases, use of unsuitable soil, improper filling of sleeves, loose planting of cuttings, use of unsuitable cuttings, heavy drip damage and inefficient drainage were responsible for unsatisfactory results. Suggestions to overcome these were offered wherever it was necessary.

There was a heavy demand for clonal cuttings from Member estates. The Cachar Advisory Branch supplied about 85,000 cuttings while the North Bank Branch supplied about 1,40,500 cuttings to Member estates.

Clonal planting and introduction of new Tocklai clones

The tempo of rapid changeover from planting out seedling teas to more suitable colones in Cachar continued. In addition to TV 1 and TV 9 which were used quite extensively, demand for the more recently released clones like TV 14, TV 16, TV 17 and TV 18 had been increasing. Amongst the Tocklai clones, TV 9 and TV 18 were suggested specially for infilling. TV 1 was also suggested in some cases.

Pest and Disease Control

Red spider continued to be the major pest in the South Bank and Cachar while its incidence in the North Bank had remarkably reduced. In general, efficient prophylactic spraying of the recommended acaricides like Ethion, Tedion, Kelthane etc. proved useful. However, the degree of control, in most cases, depended on the efficiency of spraying and the choice of the chemical. The incidence of scarlet, purple and pink mites was also reported by some of the Member estates in the South Bank and Cachar. Scarlet mite appeared mostly in young and unpruned teas. In the North Bank however, purple and scarlet mites remained the major pests. Although scarlet mite was on the decline, the severity of purple mite incidence continued to remain high and this caused heavy leaf fall during the dry months in the North Bank.

Looper and bunch caterpillars were reported by a few estates of Cachar and the South Bank. In the North Bank, looper caterpillar did not give

much trouble but the red stem borer continued to pose a problem to the estates well-known for this pest. The Advisory Officer pointed out that it was necessary to spray the frames of the bushes in time and the areas kept clean.

During the year under review, sudden outbreak of green fly (jassids) in all the Sub-areas of the North Bank and in a few estates of Cachar and the South Bank was significant. Thrips, *Helopeltis*, flush worm and aphids appeared in varying degrees. Aphids, green flies and scales were also observed in the nurseries. Thiodan was most commonly used against these insects. Sumithion also gave good control where it was used. In some estates of Cachar where Zalone was tried against thrips and green flies, excellent control was obtained. Malathion gave excellent control of scales.

Canker on shade trees resulting primarily from the attack of *Agrilus beesoni* and red rust were reported on *Albizzia chinensis*, *Albizzia procera*, *Albizzia lebbek* and *Albizzia odoratissima*. In some estates of Happy Valley in Cachar *Derris robusta* was reported to have been attacked by *Agrilus* sp. in addition to the grubs of *Cerambycid* beetle where it was thought that several species could be responsible for the canker on this shade tree.

Leaf eating insects were most prevalent on *Albizzia odoratissima*, *Albizzia lebbek*, *Derris robusta* and *Indigofera teysmanii*. Good control of most of these pests was obtained by using Thiodan or Sumithion at the recommended doses.

Red rust and black rot continued as important diseases in the South Bank and Cachar. The increase in the incidence of black rot in Cachar was possibly due to larger areas remaining unpruned during the more recent years. It was observed that blanket application of potash at higher doses reduced the intensity of red rust. Some estates in Cachar obtained good result against red rust by spraying potash along with copper fungicides.

While red rust was localised in Tezpur and Borsola Sub-areas of the North Bank, black rot was fairly heavy and due to heavy rain in May, it appeared earlier in the season. It was only after a Seminar on black rot organised by the Advisory Department that many estates took up the problem more seriously. The general feeling that this disease was associated with tea for the last 50-60 years but was never able to kill the bushes, still stood in the way of intensive treatment against it. The estates were, however, regularly reminded of the loss in terms of crop yield due to these diseases. There was an outbreak of blister blight in many estates in the eastern part of the North Bank; Upper and Central Assam. The estates were advised to remove the young shoots by plucking hard to the janam and to spray the affected areas with copper fungicides at an interval of 7-10 days.

As in the previous year, short supply of suitable insecticides, acaricides and fungicides during the peak periods of pest and disease incidences caused a serious setback in effectively controlling the pests and diseases, particularly, in Cachar and the North Bank.

Extension, Uprooting and Replanting

Contrary to earlier years, more attention was paid by the estates to extension and replacement plantings than uprooting and replanting wherever suitable land was available. Some of the reasons for this change were :

(a) The Land Ceiling Act of the Government of Assam.

(b) Inadequate rehabilitation within the minimum period of nine months specified under the Tea Board Replanting Subsidy Scheme.

(c) Non-availability of suitable tractors and equipments for deep subsoiling and

(d) Unsuitability of the uprooted areas for replanting, due either to extensive soil erosion or drainage problems. However, uprooting and replanting was done wherever it was possible.

The estates were advised that luxuriant growth of the rehabilitation crops was one of the prerequisites to harvesting the maximum from the replanted tea. Stress was always given to proper preparation

of the land and contour drainage in extension and replanting areas prior to planting out tea or rehabilitation crop. Besides *Mimosa invisa*, Guatemala and Pusa Giant Hybrid Napier, some estates were trying Java Citronella grass for rehabilitation of land.

Closer spacing either single hedge or in regular or staggered double hedge was advised for both replanted as well as for extension areas. Depending on the type of clone, soil, climatic conditions etc., a population between 11,000 to 17,500 per hectare was advised.

Agricultural Machinery

The heavy and powerful tractors were not in sight. The use of two tractors for subsoiling although suggested by this Department had not yet been very widely adopted.

Aspee Back Pack sprayers were found to be more convenient by the estates for herbicide spraying, although some of them still used the knapsack type of sprayers. Many estates continued to complain about the inefficiency of indigenously manufactured engines used in the power sprayers like Jawan, Aspee Bolo, Autoblo and Micronette which were commonly used by them. As in the previous years, it was felt by many that facilities for repairing these power sprayers locally and availability of spare parts were still lacking and unless the situation was radically improved, there would be a great setback for increasing use of these machines.

Meetings

Area Scientific Committees : There are three Area Scientific Committees on the South Bank, two on the North Bank and one in Cachar. During the year, a total of 15 meetings was held as under :

South Bank. East	...	2
,, ,, Central	...	1
,, ,, West	...	2
North Bank, East	...	3
,, ,, West	...	3
Cachar	...	4

The A. S. C. meetings were followed by group discussions. Continued interest was shown in the Area Scientific Committees meetings and group discussions (Managers' meetings) in all the Sub-areas.

Advisory Department—West Bengal

GENERAL

The West Bengal Advisory Department consists of the H. Q. office and plots at Nagrakata where the Chief Advisory Officer, West Bengal and Advisory Officer, Dooars reside, and an office in Darjeeling where the Advisory Officer, Darjeeling and Terai resides.

Consequent on reorganisation, the soil testing laboratory at Mal was closed towards the end of the year under review and the junior and subordinate staff transferred to Tocklai or Nagrakata. Dr. N. B. Chanda who was in charge of the laboratory has retired. There were no other changes in the senior staff, the Chief Advisory Officer, West Bengal, however, was away on long leave for the period July to September and the Advisory Officer, Dooars for the period December to the middle of February.

During the year the Advisory Officers in the Dooars and Darjeeling concentrated on routine advisory touring to Member estates. The Chief Advisory Officer, West Bengal was kept occupied over the supervision and conduct of field experiments and Dr. N. B. Chanda looked after miniature manufacture of experimental samples in the Dooars.

VISITS

The Advisory Officers who concentrated on routine touring, made all efforts to offer their services to every Member estate twice during the year. The table below gives the break down of the visits made in each district.

District	No. of visits	No. of Members visited	No. of Member estates in the District
Dooars	162	77	92
Darjeeling including Sikkim	82	41	47
Terai	37	17	18
Total	281	135	157

There was a large increase in the number of visits to estates in the Dooars but only a slight increase in the number of visits to estates in Darjeeling and the Terai. It is satisfactory to be able to record that out of a total of 157 members in West Bengal, only 24 (18%) did not make use of our touring services; the corresponding figure for the previous year was 45 (28%).

In addition to the visits detailed above, the Chief Advisory Officer, West Bengal, paid 50 visits to experiments including the Clonal Proving Station and the Advisory Officer, Darjeeling paid 25 visits to experiments.

Once again our advice has been generally followed and several estates have informed us that the results of our advice have been of considerable benefit to them.

In general all districts suffered from the effects of the early drought in 1971. However, rainfall was good in April and May with the result that the ill effects of drought were to a large extent nullified. Most estates finished the 1971 season with an increased total production.

A fair start to the 1972 season in all districts was promised by good early rain in January and February. This was marked by unprecedented, wide-spread hailstorms in the Dooars and Terai starting about the fourth week in March. These continued until mid May and the after effects will feature in the 1972/73 report.

Miniature manufacture of the Clonal Proving Station, Darjeeling

The principal points arising from advisory work are discussed briefly below.

1. Soil Management

(a) **Land Planning and Drainage :** These topics mainly concern estates in the plains areas of West Bengal. Land planning and drainage has been one of the most common topics for discussion. It appears that planters are quite conscious of the importance of land planning but as this is a big change from the orthodox methods, there is a certain amount of reluctance to go ahead with the new system. We have, however, tenaciously stuck to our point, that there can be no compromise between the old and the new systems, and this stance has in many cases proved effective. It has been our experience that once we have been able to sell our ideas to a manager and he has implemented them, he is generally so pleased with the results that he is unlikely to change back to the old system again.

The idea of land planning is definitely gaining popularity as we are receiving more and more requests from our Members for help, suggestions and guidance in the matter of land planning. We have, however, emphasised that good advance planning and a complete level survey of the estate are the two most important prerequisites for efficient land planning, and in this respect the memorandum on land planning (Memorandum No. 28) should be of great help.

Four years old clonal tea at Ging Clonal Proving Station brought up by step-up plucking

Plans for the realignment of drains in established tea based on the topography and soil texture have been drawn up for several Member estates.

(b) **Mulching :** We have strongly recommended mulching in young tea that has not yet fully covered the ground and in Darjeeling more estates have started planting mulching crops. However, young tea remains poorly mulched or even unmulched as the cost of mulching has generally been found to be prohibitive. In order to minimise the cost we have advised establishment of *Mimosa invisa*, Guatemala and Napier grasses at least a year ahead of extension planting, and to utilise the green crop or the grasses thus obtained for mulching at the time of planting. For the purpose of topping up of mulch, estates have been advised to plant all vacant areas, along roadsides and boundary fences with grasses.

(c) **Cultivation & Weed Control :** Cultivation has been discouraged generally in all districts excepting where it is necessary to level off the ground, prior to the start of chemical weed control and also in Darjeeling where roots have become exposed. In the Dooars large scale chemical weed control has become common. In the Terai the use of weedicides became more popular. In Darjeeling, the use of weedicides on slopes of 100% or less was advised, provided that the recommended precautions were taken to conserve soil. Advisory officers found that a considerable amount of time during advisory visits was occupied on discussing this subject.

2,4 D and Gramoxone are the two most widely used herbicides in tea. It is gratifying to report that *Mikania*, which was fast becoming a big nuisance in the Dooars tea areas, was kept under control last season by intensive spraying with 2,4-D. Estates have been asked to keep a close watch on this weed and also to control it in non-tea areas which are the potential sources of reinfestation of the tea area.

2. Pruning and Plucking

(a) **Pruning Cycles :** In the Dooars and Terai a three year pruning cycle of light prune, deep skiff and medium, light or level skiff continues to be the most popular. Advice has been given

on several occasions on suitable four year cycles. If labour for plucking and useful early rainfall are available, then the longer the cycle the higher is the crop. Special cycles for droughty areas such as the South Terai and sandy areas in the Dooars have been advised. We have stressed the fact that no one cycle will meet all the requirements of the large variety of clones and jats now planted, different frame heights and the varying soil and climatic conditions, all of which will impose limitations and these must be taken into consideration when deciding on a pruning cycle.

T.R.A. Meteorological Station at Nagri Farm T.E.

Towards the end of the period under review great interest has been shown in the question of rejuvenation of old mature tea. It has been stressed that for this operation to be successful, careful advance planning is an essential prerequisite.

The new method of bringing up young tea has by and large proved successful in the Dooars. In areas that are not particularly drought prone, it has shown good results even without irrigation. It was, however, quite clear that for this method to be successful under the droughty conditions of the Dooars and Terai the young plants must be well established in the field and perhaps for this reason wherever it was introduced in the second year after planting rather than the first year of establishment, the results had been particularly encouraging and yields upto 1700 kg/ha had been obtained in the very first year of plucking from unirrigated fields.

In Darjeeling, we have advised that the pruning cycle be geared to produce the maximum first and second flush crop, bearing in mind the limitations imposed by the ability of the labour to keep pace with the plucking rounds. As a result of this advice there has been a tendency to increase the length of pruning cycles by the introduction of a deep skiff.

(b) **Plucking :** Advice on plucking and tipping measures was frequently given. There is still plenty of scope for improvement in the plucking standard, especially in skiffed tea.

Mulching of young tea with Guatemala grass at Longview T.E.

There was a tendency in some estates for the rise of the table to be unnecessarily excessive. This has resulted in loss in crop and has been the subject for report following tours. An improvement on this front in Darjeeling reported last year, has continued in the year under review.

3. Planting

(a) **Infilling :** The good progress in this field reported in the 1970/71 report continued on plains estates. Preliminary results from an infilling experiment indicated a 25% gain in crop from infilling two plants per vacancy with a vigorous clone. In view of the severe cold weather drought often experienced in the Dooars, we have suggested spring planting for infills.

In Darjeeling, very little progress has in general been made over infilling and in spite of our repeated advice most estates failed to infill following heavy pruning.

(b) **Extension :** Although extension planting is most desirable, we have often pointed out that it is not economical to extend on land which is chemically or physically unsuitable for tea. Such land in our opinion is more profitably utilised for growing suitable mulching crops.

Extension planting is often done on thatch baris without first eradicating thatch. Consequently, the young tea suffers a great deal from thatch competition and remains backward for a considerable time. With the use of weedicides, and a cover crop, thatch can be successfully eradicated before transplanting tea and advice to this effect has been given regularly.

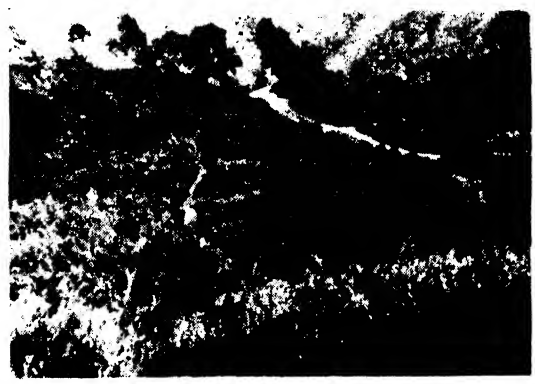
(c) **Replanting :** The pace of replanting has slowed down considerably in all areas, especially in those estates where the productivity per hectare has not shown any worth while increase, or where there is very little young tea to cushion the effect of the immediate loss in crop as the result of uprooting. Uprooting for replanting obviously must not be forgotten and on a long term view it is essential to commence uprooting of areas where rehabilitation and rejuvenation are considered a poor bet. This must, however, be preceded by increasing the yield per hectare by adopting measures such as chemical weed control, infilling vacancies with high yielding clones, reshading, longer pruning cycles, more efficient plucking and manuring.

4. **Propagation**

(a) **Seed :** Where seed is being used in plains estates, the tendency is now to use hardy jats in accordance with our recommendations. Polyclonal Stock 203 is very much in demand for it has now been proved under the conditions prevailing in the Dooars and Terai. In Darjeeling the same tendency is seen and estates are using hardy jats for planting in the lower elevations. In high elevations, no suitable jat is at present available and where planting is being done at these elevations we advise the use of proved clonal material.

(b) **Vegetative :** Routine advice on all aspects of V.P. work was common. Cleft grafting for the rapid multiplication of clonal stock is now routine on nearly all plains estates and became more of a regular feature in Darjeeling.

Following results of the trial laid out at the Nagrakata H.Q. more concrete advice on the suitability of clones for droughty areas have been given. Clones TV 1, TV 12, TV 14, TV 16 and TV 17 have all shown drought resistant properties in the trial mentioned and TV 18 in other trials. Estates are still advised to undertake their own trials before large scale planting of any one clone is undertaken. We have also warned Members of the danger of concentrating on only one or two clones.



Rehabilitation of slip area by Guatemala and Pusa Giant Hybrid Napier grasses, Bannockburn T.E

In Darjeeling there has been an increase in interest shown in V. P. work. However, only a very few cuttings of the three clones receiving interim certificates were ordered, which indicates that there is still room for a great deal of improvement in this respect.

5. **Fertilisers**

(a) **Nitrogen :** The tendency to economise on fertiliser, as was reported last year, was not so general in the year under review and most estates applied nitrogen at the recommended levels. Those estates that have continued to economise by applying low levels of nitrogen, have been warned that a loss in crop must be expected.

(b) **Potash :** The few large scale experiments initiated by the estates as well as Tocklai during 1971, did not show any positive response to potash application. Experiments are being continued and the role of reserve potash towards nutrition is

now being looked into. In the meantime estates are being advised to apply potash at 40 kg K_2O per hectare, as an insurance measure.

6. **Shade**

(a) **Green Crop :** The use of green crops has been discouraged in young tea, and instead we have advocated the establishment of *Indigofera teysmanii* to give temporary shade. Where green crop is still used there is a tendency to maintain it in young tea areas longer than necessary, every third year.

(b) **Temporary shade :** *Indigofera teysmanii* remains the most popular temporary shade tree. While its management has improved, there are still occasions when we have had to comment on the necessity of keeping this species lopped.

(c) **Permanent :** We have continued to stress that if shade trees are given a good start they will be in a better position to resist the onslaught of pests and diseases later. Goat trespass is a major hindrance to their establishment and under these circumstances we recommend the use of bamboo "guards" to protect the young shade plants.

In overshaded areas the lopping of branches, rather than the complete removal of trees, became a more common practice, following advice given to this effect.

7. **Pests & Diseases**

(a) **Pests & Diseases Bulletin :** Bulletins were issued regularly in the plains and Darjeeling areas and they continued to be popular.

(b) **Red spider :** After a bad season in 1970, red spider was very much under control in all three districts in the 1971 season. Probably the severe cold weather drought in 1970-71 kept red spider under check but the increased effort by the management towards control of red spider also played its part.

(c) **Other pests :** Scarlet and purple mites did some damage in all areas. Green flies and thrips did their usual damage in Darjeeling and advice is continually being given to control these pests. *Helopeltis*, Cockchafer, looper and red slug caterpillars were some of the other important pests reported last season.

(d) **Diseases :** Red rust was particularly severe last season in the plains areas because of the debilitating effect of the prolonged cold weather drought on young tea. Estates were forewarned to this effect and urged to take up intensive spraying against the disease in young tea areas during the appropriate period. For the control of the other important disease, black rot, we have recommended besides prophylactic and palliative spraying, reduction of shade density and knife cleaning out of the bushes at the time of pruning.

Due to continual misty and damp conditions in Darjeeling, blister blight was severe and resulted in a considerable loss in crop. The disease is easy to control and estates were continually advised to follow the standard recommendations.

EXPERIMENTS

1. Experiments and other activities at Nagrakata H.Q.

(i) **General**

It was mentioned in last year's report that the adverse effect of the severe hailstorm that struck the Head Quarter plots on the 1st April, 1971 would feature in this year's report. The damage was extensive and serious, all unpruned bushes were completely defoliated and all pruned bushes badly barked. Young plants were barked and some broken off at the collar, there was as much as 25% mortality in plots planted six months prior to the storm. Plucking did not commence until late in June and we had to release cuttings at a reduced scale in the spring period. It was not possible to complete the planting programme due to the damage caused in the nursery and the extra infilling required.

There was a big variation between clones on how they recovered from the set back caused by the hail storm and observations were taken.

Rainfall in the 1971/72 cold weather was well distributed and above average.

Green leaf harvested in the year under review was just over 20,000 kg as compared to 17,000 kg the previous year.

(ii) **Release of Tocklai Clones and Rehabilitation Grasses**

(a) **Vegetative :** Just over 2,01,000 cuttings of Tocklai release clones were distributed to Members in West Bengal. This is a decrease from the previous year due mainly to the adverse effects of the hail strom.

Just over 2700 scions of vegetative clones were released to Members, this is a large increase and reflects the fact that cleft grafting is becoming very popular.

(b) **Generative :** Nearly 2000 cuttings and just over 2000 scions of the two generative clones that make up the biclonal stocks 449 and 450 were released.

(c) **Rehabilitation Grasses :** Nearly 600 stems of Guatemala Grass and Pusa Giant Hybrid Napier Grass were released during the year.

(iii) **Experiments**

(a) **Agricultural Trial 1967/68 :** In this trial, the growth, yield and reaction to Dooars conditions of 15 Tocklai clones, 2 clones from Mal and Stock 203 are being compared. The combined yields for 1970 and 1971 were statistically analysed. In respect of the Tocklai clones, there was no significant difference between TV 1 and clones TV 4, TV 7, TV 8, TV 9, TV 11, TV 12, TV 14, TV 16 and TV 17. The yield of TV 2, TV 6, TV 10, TV 13 and TV 15 is significantly lower than TV 1 at the 5% level.

Observations on drought susceptibility during the 1970/71 drought and recovery following drought and hail indicated that clones TV 1, TV 7, TV 8, TV 12, TV 16 and TV 17 were either only slightly affected by drought or showed good recovery from drought and hail or both. All these clones together with TV 14 have shown considerable promise under the adverse conditions experienced in 1971. Clones that were badly affected by the adverse conditions were TV 2, TV 6, TV 13 and TV 15 which strongly suggests that these clones should not be planted in droughty areas.

(b) **Observation Plots Mal Clones :** Yield records for the period 1969 to 1971 and tasting results for 1971 suggest that none of the Mal clones planted in the observation plots meet the standard of either yield or quality required of a vegetative clone. The only clone that has shown some yield potential is very susceptible to drought. This clone will be tried in Assam where droughts are not all that common.

(iv) **Quality Tasting Scheme**

(a) **1969 and 1970 Trials :** The management of these plots has had the object of forming the bushes so that sufficient leaf is available for manufacture.

(b) **1971 Trial :** A small trial was planted which included one clone from an estate.

(v) **Nanda Devi Seed Bari (Stock 378)**

Intensive management has been given aimed at producing sufficient seed for release to Darjeeling estates in 1973. Facilities for irrigation have been made available. It should alleviate in future the problems associated with droughts and increase the productivity.

(vi) **Establishment of Future Release Clones**

Cuttings were taken of all clones earmarked for release in the future so that multiplication plots could be established.

2. **Clonal Proving Station, Darjeeling**

(a) **Trial A Planted 1967:** Plot yields were recorded and samples manufactured throughout the season. Assessment of liquor characters has been complicated by inconsistency between tasters and statistical designs for manufacture have been evolved to try and reduce taster variation to a minimum. The 1971 manufacture, however, supported the earlier results for the three clones given interim certificates in 1970 namely Bannockburn 157, Phoobsering 312 and Tukdah 145 were again marked high by all tasters.

It is anticipated that this trial will have to continue longer than at first thought necessary because of the problems over cup character assessment.

(b) **Trial B Planted 1968 :** Plot yields were recorded and samples manufactured. One estate clone has been discarded on account of very poor survival and low yields. One other clone shows promise of being a high yielder and the three Tocklai clones in this trial are also showing promise.

(c) **Trial C and Trial D Planted 1969 and 1970 :** Yields records were maintained and observations on growth made.

(d) **Trial E Planted 1971 :** 5 estates clones and one Tocklai clone were planted in this trial during the year.

There are now 45 clones under trial at the Proving Station and their yields and cup characters are being compared against the Nanda Devi Biclonal standard. In addition hybrid leaf from a nearby area on Ging T.E. is also used as an additional manufacturing standard.

It is appropriate to record our appreciation of the excellent co-operation received from Ging T.E. over the running of the Proving Station.

3. Field Experiments on Estates

Short and long term experiments covering a number of projects have been continued on Member estates. A complete list of Advisory Department Experiments is given in Appendix A and a list of experiments being conducted in co-operation with other departments is given in Appendix B. The number of experiments in the different districts of West Bengal is given below.

District	Advisory Dept. Experiments	Experiments conducted in co-operation with other Departments
Dooars	19	24
Terai	4	4
Darjeeling	12	9

During the year the Advisory Officer, Darjeeling laid out trials to see if controlling weeds with weedicides resulted in more soil erosion when compared to the traditional method of keeping weeds under control by sickling. The limitations of these trials are appreciated and it is accepted that further work in this field is necessary. However, they did indicate that erosion was not serious on slopes upto 100% When complete control of weeds by the use of weedicides is practised.

MEETINGS

The following annual general meetings were attended :

(i) T. B. I. T. A. by the Chief Advisory Officer, West Bengal and Advisory Officer Darjeeling, and Terai.

(ii) D. B. I. T. A. by the Chief Advisory, Officer, West Bengal.

(iii) Darjeeling B.I.T.A. by the Chief Adivisory Officer, West Bengal, Advisory Officer, Dooars.

(iv) T. A. I. North Bengal Branch by Advisory Officer, Darjeeling and Terai.

(v) T. R. A. by Advisory Officer, Darjeeling and Terai.

Area Scientific Committees

The three Area Scientific Committees in West Bengal held a total of 9 meetings, the Dooars Committee met 4 times, the Terai Committee 3 times and the Darjeeling Committee twice.

There was always a free exchange of ideas and all meetings proved extremely helpful and improved the liaison between the planter and the scientific staff.

The Dooars Committee spent sometime over making the arrangements for the Joint Meeting of all Area Scientific Committees that was scheduled

to be held in March, 1972 in the Dooars. The programme had been drawn up and arrangements had been made to receive delegates from other committees. However, the Committee had to reluctantly take the decision to cancel the meeting as it was scheduled to be held during the week preceding the general election and the Committee did not think it proper to hold it at that time.

It has since been decided to hold the Joint meeting in the Dooars in March, 1973, and the Committee look forward to entertaining and showing delegates some of the problems of growing tea in the Dooars.

MISCELLANEOUS

Soil Testing

About 2500 soil samples were analysed at Mal before the laboratory was closed in January, 1972.

Visitors

As usual a large number of visitors paid visit. to the stations at both Nagrakata and Darjeeling. Mr. M. Lamond, Chairman, TRA, paid a visit to Nagrakata and Darjeeling in March, 1972.

Manufacture

The Association again rented the miniature factory at Meenglass T.E. for the manufacture of experimental samples. While this arrangement worked better in 1971 than in the previous year, satisfactory control could not be maintained. This will be overcome when the factory at Nagrakata is built, which is scheduled for 1972.

Meteorological Stations

The two fully equipped meteorological stations at Nagrakata and Nagri Farm were maintained and regular readings were recorded. Three runoff plots were laid down at Nagrakata.

Summary of Results

ADVISORY DEPARTMENT FIELD EXPERIMENTS

Brief summaries as on 31st March 1972 of some of the experiments conducted by the Department in Member estates are given below :

Manuring

High frequency application of Sulphate of Ammonia

A number of experiments were continued to compare the effects of single and high frequency application of nitrogen at various rates on crop yield and economics of application. The levels of nitrogen ranged from 100 to 250 kg per hectare in single or in four to eight equal monthly applications. Results of some of these experiments are described below.

South Bank, Assam

During 1970 and 1971, there was no significant difference in yield in experiment AS 69 on silty loam soil when the rate of nitrogen per hectare was raised from 100 to 250 kg either in single or split doses. The application of 100 kg N/ha in four split doses gave the maximum economic return upto a marginal profit of Rs. 1.50 per kg of made tea in 1970 and upto a marginal profit of Re. 1.00 per kg in 1971.

In experiment AS 62 on loamy soil (Doolia jat) where nitrogen application ranged from 112 to 180 kg per hectare in single and split applications, doses above 112 kg N/ha failed to produce any significant differences among the nitrogen treatments even though 200 kg of K_2O/ha was applied in all the plots in 1971. It is, however, intended to continue this experiment in the same manner to see if the response from high nitrogen applications could be obtained when potash was not a limiting factor.

In two other experiments (AS 56 and AS 71) on sandy loam and silty loam soils respectively, where phosphate at 112 kg per hectare as ammophos and potash at 224 kg K_2O per hectare as muriate of potash were as basal doses after dividing the experiments into two parts, no significant response from nitrogen over 110-112 kg per hectare was obtained either in single or split doses during 1971, either with potash or phosphate.

North Bank, Assam

In experiment AN 59 on Red Bank soil (Doolia and Khowang jats), there was no significant difference in yield among the different nitrogen levels tested, varying between 112 and 247 kg N/ha either singly or in split doses.

In the experiment AN 94 on loamy sand soil also there was no significant difference among the treatments in which nitrogen application ranging from 100 to 250 kg/ha were compared in single and split applications in 1970.

Cachar, Assam

The crop analyses in 1971 of the experiment C 29 on loamy soil showed that there was no significant increase in crop over 100 kg N/ha. It was more economic to apply 100 kg N/ha either in single or in four divided doses at a marginal profit of Re. 0.50 and Re. 1.09 per kg of made tea.

In experiment C 30 on loamy soil, no significant difference in yield over 100 kg N/ha as sulphate of ammonia was obtained in the treatments which ranged upto 250 kg N/ha either singly or in split applications in 1971. This experiment was divided into two halves to compare the effects of 200 kg K_2O ha against no potash in combination with the different rates of nitrogen. In this case also application of 200 kg K_2O ha failed to show its merit.

Dooars

In experiment D 33 on sand loamy soil (Betjan tea), there was no significant difference in yield between the 110 kg N/ha applied either in two or

four equal applications and 220 kg N/ha either in single or split applications of two, four and eight in 1971. Nitrogen at 220 kg per hectare in four and eight equal applications were, however, significantly superior to single application of 110 kg nitrogen and no nitrogen treatments. There was no significant difference amongst no nitrogen, 110 kg N/ha in single and 220 kg N/ha in two equal applications.

In general, as in the previous year, there was no gain from the application of sulphate of ammonia at doses higher than 110-112 kg N/ha. The applications of high doses of potash has, so far, not shown any appreciable effect on the response of various doses of nitrogen. The split applications of nitrogen also, did not show positive gain over single applications.

Potash Manuring

Cachar, Assam

Variable response from the application of potash was obtained in the single plot high potash trials in Cachar in 1971. In general, 50, 100 and 200 kg potash per hectare showed an increase in crop over no potash application.

Dooars

In three out of four simple trials on high potash application in the Dooars, there was no significant response during 1969-70. In only one experiment, 270 kg K_2O/ha increased the yield significantly over K_0, K_{90} and K_{360} in 1970.

NPK Manuring

South Bank, Assam

As in the past five years, in experiment AS 11 on sandy loam soil, where treatment combinations of N_{100}, N_{150}, N_{200}; P_0, P_{50}, P_{100}, K_0, K_{100} and K_{200} were compared, no significant difference in yield was obtained in 1971.

In 1964, an experiment AS 44, was started on sandy loam soil to study the effects of varying rates of phosphate and potash (0, 112 and 224 kg/ha) with a constant dose of nitrogen (112 kg N/ha on Betjan tea planted in 1955). Ammophos and single superphosphate were used as two different sources of phosphate. In 1971, significant increase in yield over all other treatments was obtained when 112 kg N and 224 kg P and K per hectare were applied in combination using superphosphate as the source of phosphate. The effect of 224 kg K_2O per hectare was apparent.

In another experiment AS 51, on loamy soil (Betjan tea) started in 1964, two levels of phosphate P_0 and P_{25} and three levels of potash K_0, K_{50} and K_{100} were tried with uniform application of 100 kg N/ha. In 1971, both 50 and 100 kg K_2O/ha significantly outyielded no potash treatment. There was, however, no significant difference between 50 and 100 kg K_2O/ha. Application of phosphate failed to show its beneficial effect this year also.

Cachar, Assam

In the experiment C 28 on Bheel soil (Chandkhira jat) which was started in 1966 to study effects of different levels and combinations of NPK on young tea, two levels of nitrogen, phosphate and potash at 0 and 90 kg each per hectare and their combinations were tested. In 1971, the main effects of both nitrogen and potash were significant i.e. application of 90 kg nitrogen and potash per hectare were significantly superior to no nitrogen and no potash treatments respectively. The effect of phosphate was not significant.

Darjeeling

In experiment Dj 22 on coarse sandy loam soil (China hybrid), which was started in 1966 to compare the effect of different combinations of NPK the dose of nitrogen was kept constant at 65 kg per hectare and phosphate and potash were applied at three levels of 0, 22 and 45 kg per hectare. No significant difference in yield due to various levels of potash was obtained but with the increasing levels of phosphate significant increase in yield was obtained and response to manure over no manure was highly significant in 1970. During the same year N_{65} P_{45} K_{22} produced the highest yield as the previous year which was significantly better than N_0 P_0 K_0, N_{65} P_0 K_0, N_{65} P_0 K_{22} and N_{65} P_0 K_{45}.

In another experiment Dj 23 on sandy loam soil of similar type, however, the effects due to various doses of phosphate and potash were not significant in 1970. But all the NPK combinations were significantly superior to no manure. There was no significant difference amongst the NPK combinations.

Sulphate of ammonia Vs Calcium Ammonium Nitrate

South Bank, Assam

In experiment AS 63 on silty clay loam soil in which 110 kg N/ha as sulphate of ammonia and calcium ammonium nitrate (CAN) with and without potash were tested, there was no significant difference in yield between these two forms of nitrogenous fertilizers with or without potash. All the fertilizer treatments were significantly superior to control (no manure) in 1970. In 1971, however, 110 kg N/ha as sulphate of ammonia in combination with 100 kg K_2O/ha significantly out-yielded 110 kg N/ha as CAN. There was no significant difference between the treatments in which 110 kg N/ha was supplied from either sulphate of ammonia or calcium ammonium nitrate in combination with 100 kg K_2O/ha and 110 kg N/ha only using sulphate of ammonia as the source of nitrogen. All the fertilizer treatments were significantly superior to no manure.

Liming

South Bank, Assam

In experiment AS 77 on sandy loam soil (Betjan jat) liming at one to two tonnes per hectare reduced the crop significantly over no liming in 1971. The reduction in yield due to the application of lime at two tonnes per hectare was also significant when compared against one tonne per hectare application. There was no significant difference in yield between 100 and 200 kg nitrogen per hectare. At 100 kg nitrogen per hectare there was significant reduction in yield with two tonnes lime per hectare when compared against no lime and one tonne lime per hectare. The reduction due to liming at both one and two tonnes per hectare was significant compared to the yield of tea with no lime and 200 kg nitrogen per hectare.

In another experiment AS 78 on loamy soil (Betjan tea) of similar nature both one and two tonnes of slaked lime per hectare failed to produce any significant effect on the yield of tea in presence of either 100 kg or 200 kg N/ha in 1971.

Soil analysis of the experimental plots showed that in 1971 continuous application of one and two tonnes lime per hectare significantly reduced the soil acidity.

North Bank, Assam

In experiment AN 80 (Tinganira jat, sandy loam soil), liming did not significantly affect the yield of tea in presence either of 100 or 200 kg N/ha in 1971. As in the previous year, no significant difference in yield was observed between the two levels of nitrogen tested.

Application of lime at one or two tonnes per hectare in highly acid soil failed to show any beneficial effect in presence of either 100 or 200 kg N/ha. On the contrary, in one experiment, liming at one or two tonnes per hectare continued to depress the crop. The reduction in acidity due to the continuous application of lime was observed in one experiment in 1971.

Effect of spring and autumn application of phosphate and potash on yield of tea

Two experiments AS 95 A and AS 95 B were started on loamy sand soil in 1969 to study the effects of spring and autumn application of phosphate and potash on growth and yield of tea where weeds were controlled chemically. As in the previous year, there was no significant difference in yield in 1971.

Effect of Trace Elements

South Bank, Assam

A number of single plot trials were started by this Department early in 1971 to study the effects of individual trace elements on the yield of replanted mature tea in estates chosen from Lower, Middle and Upper Assam in the South Bank. These nutri-

ents were sprayed on TV 1 in two estates and light leafed Assam jats of tea in the rest, whose age varied from 7 to 23 years. The trace elements tried were zinc, copper, manganese and boron. As magnesium deficiency symptoms were sometimes observed in Assam, it was also included in the trials as one of the treatments. These nutrients were sprayed as 1% solution with a hand operated sprayer and four such rounds of sprayings were done at fortnightly intervals during May/June. The control plots were sprayed with water. The average response of tea is shown in Table 1.

Table 1. Average response from different micro-nutrients

Trace elements	% increase or decrease *over control (water)*
Zinc	+ 10.3
Boron	+ 2.4
Copper	— 6.0
Manganese	+ 6.6
Magnesium (major element)	+ 0.5

The above table shows that there was a gain of 10.3% in crop obtained from application of zinc, 2.4% from boron and 6.6% from manganese. Copper sulphate depressed the yield by 6% on an average.

Irrigation-cum-Pruning

South Bank, Assam

As in the previous year, irrigation again failed to show any beneficial effect over no irrigation during 1970 in the experiment on irrigation-cum-pruning (AS 68, Assam kind of tea on heavy soil). It is quite likely that the effect of irrigation during 1970 was nullified because of good distribution of rainfall already received during the cold weather of 1969-70. Although deep skiff in July produced more early crop, deep skiff in December was significantly better in terms of whole season crop. Pruning in December significantly out-yielded July pruning. There was marked reduction in crop during the main season and backend by pruning in July.

Herbicide Trials

Results of our experiments showed very good control of most of the broad-leaf weeds and shallow rooted grasses with Afalon (Linuron) which contains 50% active ingredient, at 4 kg/ha as pre-emergent application. Satisfactory control was obtained by using a cocktail of Afalon 1.0 kg + Gramoxone 1.75 l. + Surfactant 0.75 litre in 375 litres water per hectare.

Dinotaf, which contains 30% active ingredient, is a non-selective contact herbicide. 4-5 litres of Dinotaf per hectare gave satisfactory control of broad-leaf weeds like Bagracote and *Ageratum conyzoides*. However, to obtain fairly good control of grasses the rate had to be increased to 8-10 litres per hectare.

Excellent control of most of the broad-leaf weeds and shallow rooted grasses was obtained with Probe (Tunic, VCS-438) @ 3-4 kg/ha as pre-emergent application. Satisfactory control of mixed weeds was obtained by using Probe as a post-emergent application @ 5-6 kg/ha. The experiments were conducted on tea about eight years of age. Until further work is done on young tea, these chemicals should not be used in tea below three years.

Agriculture Department

General

Dr. R. N. Roy, Second Agronomist resigned from his post and left Tocklai on 29th January, 1972.

RESEARCH AND EXPERIMENT

Rehabilitation of Land

No new experiments on rehabilitation of uprooted tea areas were started. The two old experiments are being continued.

Planting and Spacing

The results of an experiment (B 8/1) with different clones, spacings and levels of nitrogen are recorded in Table 1.

Except for the 120 × 30 cm spacing, there was progressive increase in yield with increase in plant population. However, the increase in yield with higher population was less in 1971 compared to 1970 thereby confirming the trend recorded in an earlier experiment (B 104) where differences in yield between spacing ceased to be statistically significant after four years.

Table 1. Yield of made tea in kg per hectare

	Treatments	1969 L. P. 45 cm	1970 D. S. 65 cm	1971 M. S. 72 cm
Spacing	120 cm × 22.5 cm (37040 p. p. ha*)	818	1658	1854
	120 cm × 30 cm (27780 p.p. ha)	511	1274	1490
	120 cm × 45 cm (18520 p. p. ha)	563	1337	1677
	120 cm × 90 cm (9260 p. p. ha)	358	784	1184
	C. D. at P=0.05	120	293	308
Clone	T. V. 1	527	1039	1530
	T. V. 9	598	1488	1573
	C. D. at P=0.05	N.S.	207	N.S.
Nitrogen	100 kg/ha	532	1098	1336
	200 kg/ha	594	1331	1690
	300 kg/ha	—	1360	1628
	C. D. at P=0.05	N. S.	N.S.	267
	C. V.%	19.8	27.3	23.3

* p. p. ha = plants per hectare

Clone T. V. 9 significantly outyielded Clone T.V. 1 in 1970 but the differences in yield in 1971 were not significant. This is an important observation and suggests that the yield progression of Clone T.V. 9 is very steep in early years and thereafter the yield curve flattens. As against this, the yield progression curve of T.V. 1 is not so steep in the early years but continues to progress at a steady rate.

It is also interesting to find that there was response to 200 kg N/ha in 1971.

Another experiment on *jat* tea (B 8/2) started at the same time as B 8/1 gave some interesting results. The results are recorded in Table 2.

Table 2. Yield of made tea in kg per hectare

Treatment	Plant Population per ha	1968	1969	1970	1971*
120 cm × 120 cm	6944	62	234	646	964
120 cm × 90 cm	9260	82	292	714	1146
120 cm × 90 cm (doubleton)**	18520	86	329	859	1255
120 cm × 75 cm	11111	76	276	755	—
120 cm × 60 cm	13888	108	340	885	1260
120 cm × 75 cm × 75 cm	13675	98	368	1047	1359
C. D. at P=0.05	—	26	79	162	242
C. V.%	—	20.1	17.0	13.2	13.1

* The 1971 analysis was done eliminating the 120 cm × 75 cm treatment where yields were very poor due to plot heterogeneity.

** Two plants planted in one hole.

There was progressive increase in yield with closer spacing. Planting two plants in one hole (doubleton) resulted in a slight though non-significant increase in yield. As in the previous experiment the effect of closer spacing on yield became less pronounced with time.

Stump Planting of Tea

Observation plots were planted out in 1968 to compare stump planting with normal *bheti* planting. There were six treatments namely, 10 cm stumps and 22 cm stumps of 30/35 months age, and *bheti* plants of 11/15 months age. Each of the above three were planted in April/May and September/October, 1968. Stump plants were prepared by cutting the top of seedlings at 10 cm and 22 cm and then cutting the roots at 45 cm and trimming all the lateral roots. The stump planted and *bheti* planted bushes were given different pruning treatments and these are briefly described below :

Stump planted bushes

1968—Planted in April/May and September/October.

1969—Allowed to grow unplucked.

1970—Cut across at 37.5 cm in July and plucked at 67.5 cm from ground.

1971—Unpruned, plucked to *janam*.

Bheti planted bushes

1968—Planted in April/May and September/October.

1969—Tipped at 80 cm from ground.

1970—Cut across at 45 cm and decentred between 15 and 23 cm in January, 1970. Plucked at 80 cm from ground.

1971—Cut across at 45 cm and recentred in January, 1971. Plucked at 80 cm from ground.

The results are recorded in Table 3 :

Table 3. Yield of made tea in kg per hectare

Time of planting	Treatments	Made Tea		Mortality % on 1.1.72
		1970	1971	
April/May	Bheti planting	283	1114	5.5
	10 cm Stump planting	249	1646	5.3
	22 cm Stump planting	216	1517	9.2
September/October	Bheti planting	200	956	6.2
	10 cm Stump planting	183	1397	15.0
	22 cm Stump planting	116	890	25.3

Stump planted plots have given higher yield than *bheti* planted plots. Ten cm stump is better than 22 cm stump both in respect of yield and survival. April/May is a better time for stump planting because of lower mortality as well as better yield.

It is not intended to recommend stump planting in place of normal planting. Stump planting can be done when a good unused old nursery is available. Plants in stump planted plots were 20 months older than plants in *bheti* planted plots.

Bringing Young Tea into Bearing

With the object of assessing the nature of yield progression with the low tipping method of bringing up young tea, in August 1968, an area was planted with Clone T.V. 9 in single hedge of 120 cm × 60 cm and staggered double hedge of 120 × 90 × 60 cm. The yields obtained in 1969, 1970 and 1971 seasons are recorded in Table 4.

These yields are higher than what are obtained by the conventional method of bringing up young tea under similar conditions.

Plucking

The results of an experiment on plucking conducted on a medium skiffed Assam *jat* tea in 1971 are recorded in Table 5.

Standard leaf means plucking only two and a bud, large one and a bud and single soft *banjhis*. All pluckings were on a seven day round.

Table 4. Yield of made tea in kg per hectare

Spacing	Made tea in kg/ha		
	1969**	1970	1971
Staggered double hedge 120 cm × 60 cm × 90 cm (12345 p.p.ha)*	496	1303	1723
Single hedge 120 cm × 60 cm (13888 p. p. ha)	571	1605	1826

* Plants per ha

** 1969 yields recorded from July to November only

Table 5. Yield of made tea in kg per hectare

Treatments	Made tea in kg/ha	Broken back part Made tea in kg/ha	Total Made tea in kg/ha
Pluck black to janam	2149	—	2149
Pluck standard leaf and no breaking back	1454	—	1454
Pluck standard leaf and break back to janam	1558	449	2007
Pluck standard leaf over fish leaf and no breaking back	1273	—	1273
Pluck standard leaf over fish leaf and break back to level off	1487	412	1899
C. D. at P = 0.05	115	—	—
C. V. %	5.3	—	

Plucking black to *janam* gave significantly higher yield than the four treatments where only standard leaf was plucked. In two of the four treatments where no breaking back was done, the drop in yield was significant in the fish leaf system of plucking only. The weight of the broken back portion was separately recorded in the other two treatments and it is interesting to see that the broken back leaf if not discarded could contribute about 25% to the total crop. This experiment is being continued to study the long term effects of different systems of plucking as well as their interaction with prune and different forms of skiff.

Mechanical Plucking

The Tocklai Plucking Aid was compared with hand plucking throughout the plucking season. Machine plucked plots produced less total crop than hand plucked plots and quite a large percentage of the machine plucked leaf was unmanufactur-

able. There was practically no difference in the time required for plucking by machine and by hand. *Banjhi* count taken in the later part of the season showed that machine plucked leaf had higher number of *banjhis* compared to hand plucked leaf.

Manuring

A number of experiments on different aspects of manuring are being conducted at Borbhetta. The results of some of the experiments are briefly discussed below.

Nitrogen Manuring

There is no new information on forms, doses and split application of nitrogen. There are now no experiments on forms of nitrogen. The experiments on doses and split application (B 8/1, B 11/2, B 113/1) are continuing and the results continue to confirm our earlier findings that single dose application gives the same results as split application when nitrogen is applied as sulphate of ammonia. In a factroial experiments (B 8/1) 100, 200 and 300 kg nitrogen doses were compared on clonal tea planted in 1966. It is interesting to note that 200 kg per hectare nitrogen dose gave significantly higher yield compared to 100 kg N/ha.

Phosphate Manuring

The experiment (B 43 C.2) was started in 1970 to compare the efficiency of different sources of phosphate applied at 40 kg P_2O_5 per hectare in the presence of 100 kg N and 40 kg K_2O per hectare. The treatments were no phosphate, phosphate as superphosphate, rock phosphate, ammophos and nitrophosphate. There was no significant difference between treatments and it can be concluded that phosphate application in any of the above forms has not given higher yield than control.

Another experiment (B 105) where phosphate has been applied as superphosphate from 1960 at 0, 45, 90 and 180 kg per hectare has given interesting results. In this experiment phosphate application at higher doses appeared to depress crop. Only in 1970, phosphate at 180 kg/ha gave significantly less crop than control. In 1971, the trend of response had reversed and there was a tendency for higher yields in phosphate treatments. This reversal in trend is very significant because of the fact that this area has been brought under chemical weed control programme from 1970 season. The experiment is being continued.

Potash Manuring

The yield data from experiments B 5.1 and B 105 continued to give yields similar to the ones reported last year. Response to potash was obtained at all levels.

The nitrogen X potash interaction was significant in B 5.1, thus confirming last year's observation and suggesting the need for a proper balance between nitrogen and potash manuring.

An observation plot was laid out in April 1971 (S. T. T. 5/71) to study the effect of high dose of potash application on yield of medium pruned tea. The tea was of Burma *jat* planted in 1922. The two treatments consisted of a basal dose of 60 kg N and 30 kg P_2O_5 with 60 and 200 kg K_2O per hectare. The results are recorded in Table 6.

Table 6. Yield of made tea in kg per hectare

Treatment	Made tea in kg/ha
60 kg K_2O/ha	802
200 kg K_2O/ha	805

The higher dose of potash did not result in increased yield in the year of medium prune. The yield records are being kept in 1972 to see if the effects of high potash are reflected in this year.

Micronutrients

One experiment (B 108.1/2) with foliar application of zinc sulphate at the rate of 24 kg/ha in 4 splits of 6 kg/ha at two month intervals was started in the middle of 1970 season. The experiment was continued in 1971. The results obtained in 1971 (unpruned year) are presented in Table 7.

Table 7. Yield of made tea in kg per hectare and No. of shoots per kg

Treatment	Made tea in kg/ha	No. of shoots per kg
Zinc Sulphate	2383	1968
Water Spray	2204	1983
C.V.%	9.2	

Zinc sulphate gave significantly higher yield compared to water spray.

Another experiment with foliar application of Borax was started in August 1971. Borax was applied four times at 6 kg/ha as 1% solution at monthly interval in August, September, October and November, 1971 and the yield from August to November was 1055 kg/ha in Borax plots compared to 893 kg/ha in water sprayed plots.

Chemical Weed Control

Detailed trials were conducted with Probe (VCS-438) to find out its effectiveness as a pre-emergent and post-emergent herbicide and its suitability in a cocktail spray. When applied on cleeled ground at 5-6 kg per hectare it ensured satisfactory control of weeds except *Saccharum spontaneum* and *Imperata cylindrica* for about three months. As a post-emergent application at 4-6 kg/ha it ensured satisfactory control of all weeds with the exception of the above two stoloniferous grasses. Thus, it is both a good pre-emergent and post-emergent herbicide. Its toxicity to tea is also low. It gave excellent control of a mixed weed population when used as a cocktail with 4 kg Probe + 1·5 kg Dalapon + one litre Gramoxone in 400 litres water per hectare.

Cultivation of Mulch Grasses

An experiment was started in 1970 to find out the optimum cutting interval and manuring dose for Pusa Giant Hybrid Napier and Guatemala grasses. Both the grasses were similar in their response to nitrogen doses and cutting interval. The results are recorded in Table 8.

Table 8. Yield of grasses in tonnes per hectare

Treatment		Total yield in tonnes per hectare in 1971
Grasses	Guatemala	42.81
	Pusa Giant Hybrid Napier	61.96
	C.D.	5.22
Nitrogen	No Nitrogen	44.54
	150 kg N/ha	50.37
	300 kg N/ha	62.26
	C.D.	6.40
Cutting Interval	6 Weeks	46.80
	9 Weeks	52.90
	12 Weeks	57.45
	C. D.	6.40

Hybrid Napier yielded roughly 50 per cent more in the first year. It has been experienced that yield of Napier grass goes down after two to three year whereas Guatemala grass continues to give sustained yield at least for five years. The response to nitrogen is linear upto 300 kg/ha. It can be said that one hectare of grass fertilized with 300 kg N/ha will produce as much as 1·5 hectare of unfertilized grass. Twelve weeks is considered to be the optimum cutting interval for producing maximum yield.

Studies on Winter Dormancy of Tea

One experiment (B 103/2) was conducted on unpruned tea using different concentrations of gibberellic acid (GA) i.e. 0, 25, 50 and 100 pm and different intervals of spray (1, 2 and 3 months). The results are given in Table 9 :

Table 9. Yield of made tea in kg per hectare

Treatments	* Early Crop	** Main Crop	*** Backend Crop	Total Crop
T_1 — Control	498	810	349	1657
T_2 — GA 100 ppm monthly October '70—September '71	629	916	400	1945
T_3 — GA 50 ppm monthly October '70—September '71	589	838	354	1781
T_4 — GA 25 ppm monthly October '70—September '71	593	916	391	1900
T_5 — GA 100 ppm in Oct., Dec.'70, Feb., April, June & August'71	534	808	330	1672
T_6 — GA 100 ppm in Oct.'70, January, April & July 1971	466	892	423	1781
T_7 — GA 100 ppm in Oct., Dec.'70, February & April 1971	625	863	340	1828
T_8 — Water spray monthly October '70 to September '71	404	780	373	1557
C. D. at P =0.05	51	N. S.	N. S.	N. S.
C. V. %	7.9	9.4	8.2	7.8

* Early crop — January to June, 1971.
** Main crop — July to September, 1971
*** Backend crop — October to November, 1971

There is a significant increase in the early crop as a result of GA application. The effect on yield of main season, backend and total crop is not significant. The results suggest that 100, 50 and 25 ppm gave similar yields. It appears that spraying once in every two or three months is not as effective as monthly spraying for increasing early crop. The high early season yield under T_7 is however, difficult to explain.

Another experiment (B 103. 1/2) was conducted on pruned clonal tea T. V. 1. in which illumination from 4.00 P. M. to 7.00 P. M. (I. S. T.) and from 4.00 A. M. to 7.00 A. M. (I. S. T.) was compared to monthly application of 100 ppm GA. Light was provided from ordinary 60 W bulbs which were hung 60 cm above the plucking surface at the rate of one bulb for six bushes. Shade was fabricated for the bulbs so that the light remained confined to the experimental rows only. The data are recorded in Table 10.

There was not much effect of illumination or GA on the yield of pruned tea.

Leaf samples from GA treated and control plots were manufactured using two ounce roller throughout the season in 1970 and 1971. There was no significant difference in the valuations between the two sets of treatments.

Table 10. Yield of made tea in kg per hectare

Treatment	Early Crop	Main Crop	Backend Crop	Total Crop
Control	418	808	378	1604
Illumination 4.00 P. M. – 7.00 P. M.	422	900	379	1701
Illumination 4.00 A. M. – 7.00 A. M.	422	847	394	1663
GA 100 ppm Monthly October '70 September '71	454	831	355	1640

Effect of 2,4-D Application in Plucking Tea

In one trial 50 and 100 ppm solutions of 2,4-D amine salt were sprayed on unpruned bushes of Clone T.V. 1 at monthly intervals from December 1970 to April, 1971 to find out the effect of 2,4-D on winter dormancy of tea. Application of 2,4-D did not break the winter dormancy. Symptoms of 2,4-D injury did not show up clearly after the sprayings done in December, January and February. Subsequent spraying in March and April showed much more marked symptoms. There was no adverse effect on total crop.

In another trial 5, 25 and 50 ppm solutions of 2,4-D amine salt were sprayed on unpruned bushes of Clone T.V. 9 at monthly intervals from March to October to find out if small doses of 2,4-D stimulated flushing. In this trial also there was no beneficial or adverse effect on crop. In both these trials the thickness of leaves appeared to have increased as a result of 2,4-D application.

BORBHETTA FIELD EXPERIMENTAL ESTATE REPORT

Labour -The average daily attendance of labourers during the current year, compared with the last four years, is as follows :-

Year		No. of labourers engaged
1967	...	230.66
1968	...	220.00
1969	...	208.63
1970	...	188.30
1971	...	179.00

Crop— The total yield of green leaf during the current year, compared with the last four years, is as follows :-

Year		Yield
1967	...	1,29,455 kg
1968	...	1,29,021 kg
1969	...	1,44,985 kg
1970	...	1,72,868 kg
1971	...	1,74,555 kg

Of the 1971 crop, 1,69,737 kg green leaf was sold to the Jorehaut Tea Co., Ltd., and the remainder was used for experimental purpose. General plucking was stopped on 30.11.71.

Vegetative Propagation

The following supplies were made to Member estates/outstations from Borbhetta

Supplies made	1970-71	1971-72
Pretreated/fresh cuttings of vegetative clones	4,98,205	3,43,515
Scions of vegetative clones	2,122	5,540
Fresh cuttings of generative clones	—	1,500
Scions of generative clones	—	4,820
Clonal plants	300	—
Rooted cuttings of shade trees	12	—
Grass cuttings	1,100	1,300

Soils and Meteorology Department

SOIL CHEMISTRY

Cation exchange capacity of clonal tea roots

Fifteen clones of different genetic types ranging from China and Indochina through hybrids to extreme Assam forms were raised in V.P. beds for extensive laboratory investigations during the year. After five months, when sufficient root growth took place, the plants were uprooted in batches at bi-monthly intervals to measure the root cation exchange capacity (C.E.C.) by the Tocklai modified ammonium-exchange procedure. The variations of root C.E.C. values between the five months old plants of the fifteen clones were found to be about 40 milli-equivalents per 100 g dry roots. These variations tended to be narrower with age. In general, China (19/48) clones yielded highest C.E.C. values, whereas the hybrids or the extreme Assam clones yielded much lower values as reported last year. The decrease of root C.E.C. with age appears to be related to the increasing proportions of red roots developing with the age of cuttings.

Root system of clones TV_7, TV_9 and TV_{18}, when treated with growth promoting substances like 2,4-D, Gibberalic acid, and Indole-acetic acid, all at 100 p.p.m., resulted in increasing the C.E.C. values of the whole root system. These preliminary results indicate that C.E.C. value is a function of the metabolically active root system. This suggestion further gains support from the fact that root C.E.C. values decrease by about 16 to 38 per cent when fresh roots are over-dried.

The relationship between the C.E.C. values of roots, and the ratio of divalent (calcium) to monovalent (potassium) cations of the top growth was examined with fifteen different clones at bi-monthly intervals. The linear regression of the $K/\sqrt{Ca}$ values on the root C.E.C. for 5 month old V.P. plants was negative and the goodness of fit has been found to be statistically significant ($P \leqslant 0.001$, $r^2 = 0.82$). Similar relations were also observed working with seven, nine and eleven month old plants. From these results, it is concluded that with the increase of root C.E.C. (Chinary or Indochina clones) the uptake of calcium increases, whereas with the decrease of root C.E.C. (hybrids and extreme Assam clones) the uptake of potassium increases. The knowledge of this differential behaviour of the clones for the uptake of potassium and calcium can be of considerable advantage while choosing planting materials, particularly in insufficiently acidic soils.

Studies on soil nitrogen

At present our recommendations on nitrogen manuring are based on actual field response measured on a few sites. In view of the large expenditure on nitrogen fertilisers, the need for a precise soil test to predict nitrogen requirement, is evident.

The current practice of organic matter test for evaluation of the total stock of soil nitrogen is correct. Regression of the total nitrogen content on organic matter has been worked out with a fairly large number of soils from various regions of North East India. The relationship was linear and the goodness of fit was found to be highly significant ($P \leqslant 0.001$, $r^2 = 0.96$). However, for making nitrogen fertiliser recommendations on the basis of soil test, one needs to have an idea of the available fraction rather than the total stock.

For establishment of an "availability index", release of mineral nitrogen (in this case ammonia only, nitrate being absent) was measured with a few fertilised and unfertilised soils keeping them under waterlogged conditions and incubating at 30°C for a period of six weeks. Most of the soil nitrogen, innate or added, was released during the first two weeks. Thereafter, the release of mineral nitrogen appears to slow down appreciably. The incubation technique for two weeks was then applied to a large number of soils from different areas, and the correlation between the total and the released ammonia nitrogen examined. It was found that large differences can exist between the mineral nitrogen or the "availability index" of different soils having the same total nitrogen content but differing in their textural types. Data also suggest that soils belonging to a particular textural type can have a fairly well-defined nitrogen releasing characteristics. Regression of the mineral nitrogen on the total nitrogen content has been worked out

with sandy loam type of soils. The relationship was linear, and the goodness of fit was found to be highly significant (P0.≤001, r^2=0.76).

The study also suggest that the release of mineral nitrogen is not dependant upon soil pH status, where the pH of the soils varied between 3.5 and 6.0 and the soils represented different tea growing areas of North East India.

The preliminary results indicate that there is a need for correlation studies between the nitrogen "availability index", and the nitrogen uptake by tea or an indicator crop using soils of various textural types under green-house conditions.

Studies on soil phosphate

The generally non-responsive behaviour of applied phosphate fertilisers to mature tea has been a subject for consideration during the past years. *Before deciding on the future line of work, it was* thought necessary to examine the changes in the various soil phosphate fractions as a result of long-term manuring with single superphosphate at various levels.

1. Fractionation of soil phosphate (residual effects of Superphosphate manuring)

An attempt was made to estimate the various fractions of soil phosphate in two long-term N. P. K. experiments, one (B. 105) sited at Borbhetta (Mid-Assam) and another (D.1.) at Kalchini (Eastern Dooars). Both these experiments were started in 1958. Soils of Borbhetta and Kalchini belong to sandy loam, and silty loam types, respectively. The results of the fractionation study are given in Table 1.

Table I Different forms of soil phosphate as influenced by long-term phosphate manuring at varying levels

Site	Fertiliser treatment kg per hectare N. P. K.			p. p. m. aluminium phosphate	p. p. m. iron phosphate	p. p. m. calcium phosphate	p.p.m. organic phosphate	p. p. m. total phosphate	
								≒ III to VI	estimated
I	II			III	IV	V	VI	VII	VIII
Borbhetta	90	0	0	66	118	80	172	436	438
,,	90	45	0	135	140	80	266	621	560
,,	90	90	0	184	180	80	281	725	700
,,	90	180	0	200	260	80	360	900	969
,,	(Mean)			146	174	80	270	670	668
Kalchini	0	0	0	135	190	980	500	1,805	1,925
,,	0	45	0	200	230	1,115	562	2,107	2,300
,,	0	90	0	222	250	1,065	688	2,226	2,650
,,	(Mean)			186	223	1,053	583	2,046	2,292
,,	90	0	0	145	220	800	594	1,759	1,925
,,	90	22.5	0	238	290	800	844	2,171	2,300
,,	90	45	0	245	380	790	938	2,353	2,475
,,	90	90	0	290	420	789	1,188	2,678	3,000
,,	(Mean)			230	328	792	891	2,240	2,425

It is seen that

(i) Eastern Dooars soil has almost three and a half times phosphate content compared to the Mid-Assam soil;

(ii) the dominating inorganic phosphates in Eastern Dooars and Mid-Assam soils are calcium and iron phosphates respectively;

(iii) all the phosphates, except calcium phosphate, increase progressively with increasing levels of superphosphate application at both sites;

(iv) it appears that the increase of inorganic phosphates is about one and half times than the increase of organic fraction at Borbhetta, whereas in Eastern Dooars the opposite is true;

(v) at both these sites organic phosphate comprises about 40 per cent of the total phosphate;

(vi) the close agreement between the estimated and the calculated total phosphate contents show that the major soil phosphate fractions are accounted for in the fractionation study.

2. Fractionation of soil phosphate (unmanured soils of various regions)

Soils from different regions of North East India were fractionated to find out the distribution pattern of various native soil phosphate fractions. Results suggest that aluminium phosphate ranges between 0-150 p.p.m. with an average of 45 p.p.m., iron phosphate ranges between 50-400 p.p.m. with an average of 90 p.p.m. In general, iron phosphate predominates in our tea soils, although under special situations like those of Kalchini grey silty loam, calcium phosphate predominates. Out of the three main inorganic fractions, aluminium phosphate accounts for lowest percentage of the total phosphate reserve. The organic fraction, generally, varies between 30-50 per cent of the total phosphate, with an average of 40 per cent.

It is generally believed that aluminium phosphate is associated with low pH. However, in this preliminary study, although "available" aluminium is found to be linearly related to soil pH, the relationship between aluminium phosphate and either pH or "available" aluminium does not follow a clear trend. However, there is a suggestion that aluminium and iron phosphates increase with lower pH, whereas calcium phosphate tends to increase with higher pH. Since a vast majority of our tea soils are now highly acidic, phosphate uptake of tea may be dependent upon these two fractions.

The reductant soluble iron phosphate varied between 30 to 600 p.p.m., with an average of 230 p.p.m. This phosphate being coated with iron-oxide is least available for plant uptake and is of no significance for nutrition. The "occluded" phosphate, another unavailable phosphate fraction, has been found to be absent in tea soils.

As a result of the above fractionation study, it is suggested that an ammonium fluoride—sodium hydroxide extraction solution might be a useful extractant for routine estimation of available phosphate (instead of the current Bray's method), since both aluminium and iron phosphates ("active" fraction for most of our soils) will be accounted for in the availability measurement.

Studies on soil potash

A paper was presented in the Tocklai biennial conference, 1972, on the importance of potash manuring, which covers a large part of the last year's researches carried out on the soil potash problem. Briefly, the subjects are :

(a) estimating the potash requirement by tea through growth analysis;

(b) depletion of soil available potash through long-term manuring with sulphate of ammonia;

(c) frequency distribution of available potash in tea soils, and forms of potash in two major types of soils;

(d) the relationship between clay and available potash contents of tea soils;

(e) effects of building-up dressings of potash fertiliser on the soil potash status at various depths down to three feet;

(f) soil test—crop correlation studies with various methods to find out a reliable test for potash fertility evaluation programme in tea areas;

(g) preliminary results of field trials on mature tea with various levels of potash fertiliser;

(h) Potash deficiency and reliability of the use of soil or leaf analysis as a diagnostic aid;

(i) the interim recommendations on the practice of potash manuring.

For details of results please see pages 34-44, Vol. **18,** No. 2, December, 1971 issue of "Two and a Bud".

An important point which has emerged from these studies is that besides the available or exchangeable soil potash, the rate of release of non-exchangeable potash can also be an important parameter for correct understanding of the potash nutrition beyond soil-type boundaries.

1. Fractionation of soil potash

As a first attempt, soils from the various regions of North East India have been fractionated into three forms namely, water-soluble, exchangeable, and the non-exchangeable forms which together constitute the "active" form in our soils.

In Assam soils, water-soluble form ranges between 10 to 40 p.p.m., with an average of 18 p.p.m.; the exchangeable form ranges between 20 to 150 p.p.m., with an average of 60 p.p.m.; the non-exchangeable form ranges between 180 to 500 p.p.m., with an average of 300 p.p.m. In Dooars, water soluble form ranges between 10 to 30 p.p.m., with an average of 18 p.p.m.; the exchangeable form ranges between 30 to 150 p.p.m. with an average of 65 p.p.m.; the non-exchangeable form ranges between 300 to 2,800 p.p.m., with an average of 1,200 p.p.m. In Darjeeling and Terai, water soluble form ranges between 10 to 30 p.p.m., with an average of 20 p.p.m.; the exchangeable form ranges between 40 to 200 p.p.m., with an average of 90 p.p.m.; the non-exchangeable form ranges between 460 to 2,800 p.p.m., with an average of 1,700 p.p.m.

The fractionation data show clearly that West Bengal soils have very much higher potentially available potash contents (non-exchangeable) compared to the Assam soils. The variations in response from applied potash fertilisers under Assam and West Bengal conditions can possibly be tied up with the fate of this important fraction.

A laboratory method has been standardised, where cation exchange resin is used to extract specifically non-exchangeable potash from our soils. About 50 p.p.m. non-exchangeable potash was released from soils of a long-term experiment at Borbhetta. The rate of release was found to be pretty fast. It also appears that the residual effects of potash manuring under Borbhetta conditions confine to exchangeable or available fraction only, since no difference was noted between the released non-exchangeable potash contents of the un-fertilised and the fertilised plots. Before application of the method for advisory purpose, it is necessary to examine the relationship between resin-extracted non-exchangeable potash and the potash uptake in exhaustion experiments.

2. Seasonal fluctuation of soil potash

During the last year a long-term experiment at Borbhetta (B. 105) has been sampled at monthly intervals down to 90 cm, the depths of sampling being 0-15 cm, 15-45 cm and 45-90 cm. The sampling confined to four treatments namely, K_2O at levels 0, 45, 90 and 180 kg per hectare. The results suggest that :

(a) Changes of available potash in soils follow the same trend in all the three soil layers examined.

(b) From January to March, available potash content increases with progressive drying out of the soil. This increase is likely to be

due to lower uptake of potash under moisture stress, and should not be relied upon for prediction of potash requirements by tea.

(c) From April to August, appreciable fluctuations are observed (generally alternate rise and fall) attaining a peak rise in August and, thereafter, a steady decline takes place until January. However, these fluctuations are more marked in the manured plots with higher levels (like 90 and 180 kg/ha K_2O) than in the case of un-manured or low potash plots. The fluctuations observed during this period is associated with crop withdrawal and release due to weathering.

(d) The depletion of available potash from the top 15 cm layers between the period August-January has been found to be 90 and 70 kg/ha (45 and 35 p.p.m) for K 180 and K 90 plots respectively. The unmanured and the K 45 plots over the same period lost only 54 kg/ha or 27 p.p.m. available potash.

Seasonal variations were also confirmed in three other Assam trials. It suggests that for fertility evaluation with respect to potash, the soil samples in Assam should best be collected from August to January, thus avoiding the period showing sharp seasonal variation in available soil potash. Similar studies are being carried out for the second year in Western Dooars, where the wet and dry seasons are somewhat different from that of Assam.

3. Seasonal fluctuation of leaf potash

From the same long-term experiment at Borbhetta (B. 105) two and a bud plucked shoots, internodes, and the third leaf of clone 20/23/1 were analysed at fortnightly intervals during the last year from May to November. Data were statistically analysed, and the effect of season on the concentrations of potash in the shoot, third leaf and internode has been found to be significant ($P \leq 0.001$), irrespective of the treatments as seen in Table 2.

Table 2. Seasonal changes in the concentration of potash in plucked shoots, third leaf and internode (data expressed as percentage on dry weight basis)

Months	Concentration of potash in leaf and internode		
	Two and a Bud	Third leaf	Internode
May	1.98	1.95	2.85
June	1.56	1.73	2.52
July	2.14	2.02	3.28
August	2.07	2.15	3.21
September	2.03	2.08	2.90
October	2.12	2.10	3.02
November	2.18	2.18	3.04
C.D. (at 5%)	0.07	0.07	0.10
,, (at 0.1%)	0.11	0.11	0.17
(C.V. %)	4.73	4.64	4.80

The data suggest that :

(i) Concentration of potash in the internode is relatively much higher than in either third leaf or Two and a bud plucked shoot.

(ii) Like soil available potash contents, an alternate rise and fall of the potash concentrations in all the plant fractions are noted until August when peak rise has been observed. From August to Novem-

-ber virtually little change takes place in the leaf or internode potassium concentrations. This is in agreement with the continued depletion of soil available potash over the same period.

(iii) It is tentatively suggested that for diagnostic aids, the internode samples collected during the active growth period (i.e. July/August) will be a good criterion.

4. Leaf or internode potassium concentration as affected by manuring

The effect of long-term potash manuring at various levels on the third leaf or internode concentration of potash has been found to be significant ($P \leq 0.001$), but the same has not been true for plucked shoots. Table 3 shows how concentrations of potash in the third leaf or internode is affected by manuring.

Table 3. Effect of manuring on potash concentrations in plant part (data expressed as percentages on the dry weight basis)

Potash (K_2O) applied, kg/ha		Concentration of potash in leaf and internode		
		Two and a Bud	Third leaf	Internode
0		2.02	1.97	2.84
45		2.03	2.08	3.03
90		2.04	2.05	3.09
180		2.12	2.18	3.18
C. D.	(at 5%)	N. S.	0.09	0.12
,,	(at 1%)	N. S.	0.13	0.18
	(C.V.%)	10	10	9

The data further suggest that the concentrations of both third leaf and internode potash increase in the order : $K_{180} > K_{90} = K_{45} > K_0$.

5. Correlation studies between soil and leaf potassium, as well as yield

The correlation study has shown that both internode and third leaf potash concentrations are linearly related to soil available potash. The goodness of fit has been tested, and found to be statistically significant ($P \leq 0.001$; $r^2 = 0.87$, between soil available and internode potash; $r^2 = 0.79$ between soil available and third leaf potash). Correlation studies between yield and either internode potash or soil available potash suggest that these diagnostic aids can be used with advantage for prediction purpose of the potash fertiliser requirement by tea.

6. Influence of long-term superphosphate manuring on leaf potash concentration

In 1969-70 Annual Report, p. 35, it has been stated that leaf analyses show an inhibitory effect of calcium contained in the superphosphate on the uptake of potash.

A follow up of the observed inhibitory effect of calcium on the potash uptake was carried out during 1971 by analysing monthly two and a bud plucked shoot, third leaf, and internodes of Tingamira *jat* of tea from July to December. The inhi-bitory effect of calcium on the potash concentrations of both plucked shoot and the third leaf (but not internodes) has been confirmed ($P < 0.01$) inspite of the seasonal variations. Detailed results will be published elsewhere. For general interest, mean data on the potash and calcium concentrations in the leaf and internode as affected by long-term superphosphate manuring are given in Table 4.

Table 4. Concentrations of potash (K_2O), and calcium (CaO) in leaf and internodes

Phosphate (P_2O_5), applied kg/ha	Two and a Bud		Third leaf		Internode	
	Potash	calcium	potash	calcium	potash	calcium
0	2.46	0.59	2.29	0.78	3.30	0.82
22.5 (45 in 1971)	2.37	0.66	2.19	0.87	3.22	0.89
C. D. (at 1%)	0.05	0.04	0.07	0.03	N. S.	0.03
,, (at 0.1%)	0.07	0.05	0.10	0.04	—	0.04
C. V. %	3.9	11.4	6.2	7.9	—	6.4

7. Field trials on mature tea with nitrogen, phosphate and potash

The multiple regression analysis (see 1970-71 Annual Report, p. 38-39) could not be carried out in the computer because of the other commitments on the part of the Statistics Department.

SOIL PHYSICS

Studies on soil water management

During 1971 basic investigations concerning soils, run-off, and ground water table have been carried out to understand the need for drainage and conservation, and, if possible, to derive guidance for future work. Additionally, researches on the water requirement by tea received a great deal of attention.

1. Drainage investigations

A reconaissance survey has been carried out in the South Bank tea districts of Assam to evaluate the physical properties of the soil layers down to the effective root depth and ascertain the drainability. Physical investigations confined to determination of bulk density, texture, field capacity moisture (F. C.), wilting point moisture (W. P.), available water in the effective root zone (from F. C. and W.P.), total pore space (capillary and non-capillary), air filled pore space (non-capillary or drainable pore space), permeability, and pF curves or moisture releasing characteristics at various applied suctions. The detailed results of the preliminary survey will be published elsewhere, but, for general interest, only some of the important aspects will be dealt in this report.

(a) Texture

The survey shows that soils in the South Bank vary from loamy sand to silty clay loam types. The predominating textural types in the various tea districts are as follows :

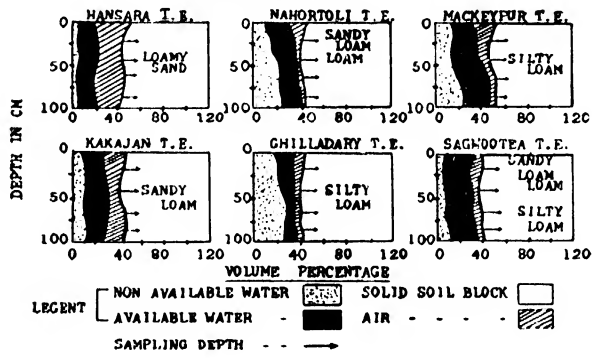
District	Textural type
Doom Dooma	: Loamy sand to sandy loam
Dibrugarh	: Loam to silty loam
Moran	: Loam to silty loam
Sonari	: Silty loam to silty clay loam
Nazira	: Silty loam to silty clay loam
Jorhat	: Sandy loam to loam
Golaghat	: Silty loam to silty clay loam
Nowgong	: Silty loam to silty clay loam.

Besides, within a single profile, shallow layers of different textural types have also been found to alternate, although the subsoil layers are continuous and interconnected. Within the 100 cm depth of sampling heavy impervious clay stratum has not been found. This shows that these soils are basically drainable.

(b) Air capacity

Fig. 1 shows the proportions of water, air and solid matter in a few South Bank soils at fields capacity at various depths of the profile.

FIG:1. RELATIONSHIP BETWEEN SOIL,WATER AND AIR AT FIELD CAPACITY



It is seen that the volume of air is satisfactory in the case of loamy sand or sandy loam type of soils, whereas the air-capacity gets restricted in the subsoil layers when the soil is of silty loam or silty clay loam type. This is so even when a sandy loam type of soil overlies silty clay loam subsoils. It can be concluded that a majority of the South Bank soils have restricted air-capacity in the subsoil layers at about 45—50 cm from the soil surface. The implication of this observation is that the subsoils are apt to remain wetter than at field capacity (reduced air content) during the monsoon months for a long period. To minimise the period when moisture content is above field capacity, the necessity of deepening and re-alignment of the existing drains in the mature tea areas should be appreciated.

(c) **Permeability**

In 1970-71 Annual Report, p.41, it has been mentioned that modifications of a technique, developed by the American Society of Soil Science, are being tried out for reproducible measurement of the permeability of soils under laboratory conditions. This has now been accomplished, as should be evident from results shown in Table 5.

Table 5. Results of standardisation of a laboratory technique for permeability determination (data expressed as $x \times 10^{-4}$ cm/sec., where x—permeability data (K))

Soil	Site	Replicate	Time of observation after setting				
			30 min	60 min	90 min	120 min	150 min
Sandy loam type	I	1)	16.50	13.20	9.90	9.90	9.90
		2)	13.20	11.55	11.55	11.55	11.55
		3)	11.55	9.90	9.90	9.90	9.90
		4)	11.55	9.90	9.90	9.90	9.90
"	II	1)	8.25	8.25	8.25	8.25	8.25
		2)	9.90	9.90	9.90	8.25	8.25
		3)	11.55	9.90	9.90	8.25	8.25
		4)	11.55	11.55	11.55	9.90	9.90
"	III	1)	9.90	8.25	8.25	8.25	8.25
		2)	9.90	8.25	8.25	8.25	8.25
		3)	11.55	9.90	9.90	9.90	9.90
		4)	16.50	13.20	13.20	13.20	13.20
"	IV	1)	11.55	11.55	9.90	9.90	9.90
		2)	8.25	9.90	8.25	8.25	8.25
		3)	11.55	13.20	9.90	9.90	9.90
		4)	11.30	13.20	11.55	11.55	11.55
C.V. p.c.			20.25	17.12	14.11	15.06	15.06
S.D.			1.76	1.83	1.41	1.46	1.46
S. E.			0.44	0.46	0.35	0.36	0.36

From the above results, it has been decided to take observations after 90 minutes from the time of setting or charging the permeability cells, when the range of fluctuation between duplicate measurements can only be + 0.70.

The method is now being employed to find out the frequency distribution of K or permeability values within different regions, as well as the relationship between observed variations with textural characteristics. Results so far suggest that Darjeeling and Terai (North) soils are far more permeable than those of the valley soils in Assam (ranges being K = (20—50) $\times$ 10^{-4} cm/sec. for Darjeeling and Terai soils, as against K=($\angle$10-20) $\times$ 10^{-4} cm/sec. for valley soils).

Further, laboratory estimate of K (permeability) has been compared with *in situ* measurement of K (where a water table is present in the case of sandy loam soils, and the agreement between the two

methods has been found to be good. Relationship between the two methods of measurement at various sites is now under study.

From the exploratory data on the permeability of South Bank soils, horizontal spacing between the two subsidiary drains has been calculated using Hooghoudt's equation. In the calculation, the following main features are taken into consideration :

(a) drainage in the South Bank to cope with a rainfall of 76 cm a month or 2.54 cm per day.

(b) The maximum ground water level midway between the two parallel drains not to rise within 90 cm from the land surface.

(c) the depth of the impermeable layer is, on an average, three meter below the land surface as has been observed. Spacing data are shown in Table 6.

Table 6. Permeability of typical South Bank soils and calculated drain spacings

Soil type	Depth cm	Permeability, K × 10-4 cm/sec.	Mean K × 10-4 cm/sec.	Drain spacing (m)	Depth of drains (m)
Loamy sand	20	47.27			
,,	40	33.35	45.75		
,,	60	41.17	(3.96 m/day)	45-55	1.0-1.5
,,	90	61.00			
Sandy loam	20	11.25			
,,	40	10.65	9.69		
,,	60	9.90	(0.84 m/day)	20-25	1.0-1.5
,,	90	6.97			
Loam	20	8.82			
,,	40	6.74	6.94		
,,	60	5.42	(0.60 m/day)	15-20	1.0-1.5
,,	90	6.76			
Silty loam	20	4.83			
,,	40	4.49	4.91		
,,	60	4.73	(0.42 m/day)	12-15	1.0-1.5
,,	90	5.64			
Peat	20	173.40	14.98 m/day	90-100	1.0-1.5

2. Run-off and Erosion studies

In 1970-71 Annual Report, p. 39, the basis of run-off and erosion studies at Tocklai has been described. It has been mentioned earlier that after preparation of the run-off plots with transported soils, these plots were allowed to settle down to the desired density. However, in spite of fallowing for a period of almost two years, the erosive loss of soils appear to be considerable. The conditions of the run-off plots at the time of measurement of soil losses can be considered as comparable to those of uprooted and cultivated areas just been planted out with Guatemala. Preliminary results on the soil and nutrient losses from the run-off plots at different slopes are shown in Table 7.

Table 7. Average soil and nutrient losses from erosion plots of different slopes

Percentage slope of run-off plots	Rainfall intensity (peak) mm/hr.	†-Average soil loss in kg per hectare	†-Average loss of nutrients in kg per ha († each data average of eight estimates)		
			nitrogen	phosphate	potash
6	20.6 mm/hr.	1,345	3.28	1.75	9.03
3	,,	686	1.32	0.82	3.91
2.5	,,	616	1.41	0.79	4.03
1.0	,,	541	1.40	0.75	3.97

From the above data it is seen that with a moderate intensity rainfall considerable soil and nutrient losses can occur. Further, the losses from plots with six per cent slope are more than double of the quantities lost from all other slopes included in this study. Admittedly, these data can be over-estimates because of the still unsettled soils in the plots, but they should serve as good indicators of what could really happen in replanted slopes, specially when they are left bare following cultivation or even during the first two years of replantation.

The beneficial effects of mulching on the physical reduction of run-off, as well as improving the rainfall acceptance properties of the soils have also been marked in this experiment.

3. Water requirement studies

Evaporation (E_0) at Tocklai and other meteorological sub-stations were calculated from the weather data by the Penman's method for the last few years. For making accurate use of these data, crop coefficient has now been determined. The actual quantity of water tea needs for optimum growth can now be determined using E_0 data and the crop coefficient.

(a) Soil moisture depletion pattern under purned and skiffed tea, and determination of crop coefficient :

During the dry period of 1971-72, beginning from December to April, depletion of soil moisture was followed in both pruned and skiffed (medium) plots at Tocklai. Soil moisture was estimated at weekly intervals down to 90 cm by successive sampling of each 15 cm soil layers. Average monthly moisture contents at different depths under pruned and skiffed teas are shown in Table 8.

Table 8. Average soil moisture content during December—April under pruned and skiffed teas
(data in cm of water)

Month	Type of pruning	Depth of soil layers (cm)						In 90 cm effective root depth
		0 –15 cm	15 –30 cm	30 –45 cm	45 –60 cm	60—75 cm	75 –90 cm	
December	Light prune	4.1	4.1	4.4	4.5	4.4	4.2	25.7
	Medium skiff	3.4	3.8	4.1	4.1	4.1	4.0	23.5
January	Light prune	3.9	4.3	4.6	4.5	4.4	4.4	26.1
	Medium skiff	3.4	3.7	3.8	3.8	3.9	3.9	22.5
February	Light prune	4.1	4.5	4.6	4.8	4.6	4.4	27.0
	Medium skiff	3.8	4.0	4.1	4.2	4.0	3.9	24.0
March	Light prune	3.7	4.0	4.2	4.3	4.2	4.2	26.6
	Medium skiff	3.4	3.7	4.0	3.8	3.8	3.8	22.5
April	Light prune	4.5	5.0	5.3	5.3	4.9	4.7	29.7
	Medium skiff	4.4	4.9	4.9	5.3	4.8	4.7	29.0

The soil moisture status, as expected, has been found to be higher at all depths down to 90 cm in the case of pruned tea compared to its skiffed counterpart. It appears that, on an average, 2.74 cm per month more water is transpired from a 90 cm effective profile by the skiffed tea as compared to the pruned ones. During 1971-72 between December and March, about 16.5 cm rain fell. The soil moisture depletion under pruned and skiffed teas over the period has been found to be 35.3 and 47.1 cm respectively from the weekly moisture data. The total evaporation (E_0) during the same period has been 43.0 cm as calculated by the Penman's method. If we consider E_t =47.1 cm, and E_0 =43.0 cm, then $\frac{E_t}{E_0}$ or crop coefficient equals 1.09, a value in close agreement with cool season value of 1.12 worked out for Bangladesh tea by Van Der Laan. Laycock, however, recommends a crop coefficient of 0.85 for tea, apart from the period after pruning. However, this exercise will be continued until April, 1973, in view of the rather wet cool season prevailing during 1971-72. The above-mentioned value of crop coefficient should, therefore, be considered as tentative.

(b) **Moisture storage capacity of soil**

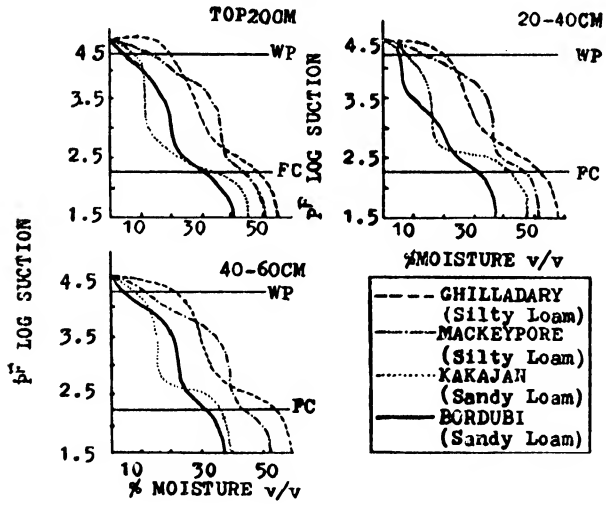
Available water contained in effective root profiles has been estimated under varying conditions in the South Bank of Assam. Profile studies show that roughly 18 cm of water can be contained in the root profile, except for the loamy sand type of soils which contain about 14 cm of available water. Admittedly this survey should be further extended especially in droughty areas; but for the South Bank, where

usually sandy loam overlies silty clay loam or vice versa, the available water capacity per 90 cm effective root profile can be tentatively taken as 18 cm.

(c) pF or soil moisture characteristics

Soil moisture characteristic or soil moisture retention curves for a number of South Bank soil profiles (at different depths) have been prepared, firstly to understand the affect of texture and structure on the moisture retention curves, and secondly to calculate the effective pore-size distribution (i.e. the volume of different classes of pore sizes) in these soils. The curves are prepared by determining soil moistures at various applied suctions between pF 2.0 to 4.2 or between 1/10th to 15 atmosphere. Detailed results will be published elsewhere. For general interest, moisture characteristic curves of four different soils in the South Bank are shown in Fig. 2.

FIG:2. MOISTURE RELEASE CHARACTERISTICS



Two of these namely, Ghillidhary and Mackeypore (Group A) belong to silty loam to silty clay loam type, and the remaining two Kakajan and Bardubi (Group B) belong to sandy loam to loamy type of soils. It is seen that the curves for the different depths (either in the case of Group A or Group B) for any particular soil are nearly of the same shape. The slopes of the curves of group A, however, differ largely from those of group B soils, irrespective of depth. Group A soils have not only higher quantities of available water, but the slopes of the curves being gradual, these are likely to transmit water for a longer period than Group B soils which are associated with steeper slopes, i.e., those likely to transmit water readily. The slopes of the different soil-moisture characteristic curves are calculated to find out the change of water content per unit change of soil-water or matric suction, and ultimately to group the soils according to these changes or, in other words, their differential water capacities.

(d) Relationship between gravimetric soil moisture and available water

Because of the failure to measure soil moisture with gypsum blocks in the past, it is thought necessary to work out regressions between the total gravimetric moisture content and the available moisture for each soil type. Establishment of an equation would enable us to transform gravimetric data into availability measurements at any time. Both total and available soil moisture were determined at weekly intervals for a period of four months at two different experimental fields belonging to the sandy loam type of soils. The determinations covered the entire effective root profile, where successive 15 cm soil layers were sampled down to 90 cm. The soil moisture was compared on a 90 cm profile basis, and the regression between the total and the available soil moisture was worked out. The goodness of fit was tested statistically and found to be significant ($P \leqslant 0.001$, $r^2 = 0.94$). The equation relating this comparison is :

$y = -4.19 + 0.9980\ x$, where y = the available water (i.e. Field capacity minus wilting point moisture), and x = the total moisture (by gravimetric method.)

It appears that roughly three-fourth of the total moisture content in a sandy loam or loamy soil remains available to the plant.

Studies on ground water table

In the tea areas often flooding of the soil surface occurs, besides the build up of high water table in monsoon either in low lying areas or in inefficiently

drained lands. The effects of different moisture levels on the growth of tea have been studied under artificial conditions with the object of deriving preliminary information.

(a) **Reaction of tea to different levels of water supply**

Two series of experiments were carried out with potted clonal plants for finding out the effects of different intensities of flooding on the growth of tea. The clones included in this study are KAMET FB/16, TV1 and TV7, which are broadleaf Assam, hybrid, and extreme China types respectively. The treatments were : T_1 = Field capacity
T_2 = Half root-zone submerged
T_3 = Full root-zone submerged
T_4 = Tea bushes half submerged
T_5 = Tea bushes fully submerged.

Results of these experiments suggest that:

(i) Clones do not differ between themselves as far as their reactions to excess water levels are concerned.

(ii) Fully submerged plants died at the end of fourth week, although defoliation and blackening of stem started within two days from the start of the experiment.

(iii) Half submerged and full root-zone submerged plants died at the end of seventh week, although defoliation and blackening of stems started within 2-3 weeks' time in a severe way.

(iv) Half root-zone submerged plants remained in moribund condition for three months, and then with the growth of new roots above the ground water table, the plants started showing signs of active growth once again.

(v) Field capacity plants, as expected, showed uninterrupted growth throughout the period of these experiments.

Further, it has been observed in a separate series of experiment that on alternate wetting (under shade) and drying (either in the open sun or in shade) all tea bushes fully submerged and dried in the open died within a week. Similar alternate wetting and drying operations in the case of other three treatments (T_2, T_3 and T_4) resulted only in producing sunscorch effects on the plants exposed to sun. Those plants which are alternately fully submerged and dried in shade survived for a period of about a month or so. Thus recurrence of short-term floods can be much more detrimental than flooding continuously over a longer period particularly when the former alternates with exposure to open sunshine.

(b) **Effect of water tables on the growth of tea**

In 1970-71 Annual Report (p. 41), the set up of the experimental tanks, where water tables have been kept fixed at 45, 90 and 135 cm has been described in details. In the early part of November, 1971, when soils settled down in the tanks, eighteen month old clonal plants, viz. TV1 and S3A/3 were

45 CM 90 CM

Plate 1. Growth of Tea in Tanks, Water Tables at 45 and 90 CM from the surface

planted out at a spacing of 25 × 21 cm. Plate 1 shows the growth of the plants after eight months from planting in the tanks having water tables at 45, 90 and 135 cm from the surface.

Observations on the number of infills, tipping, the nutrient (N, P and thin) losses from the root zones of plants, as well as weekly gravimetric moistures and the moisture tensions are now being recorded.

Summary of Meteorological Data

Meteorological conditions in ten-day units have been given for 1971 for all the four meteorological sites, and a summary of the observations for 1970 is given in the Appendix.

Research and advisory analysis

About 35,000 soil analyses have been made during the year. The break-up is as follows :

(i) **Research :** For Soil Department's as well as for other departments, 12,874 estimations.

(ii) **Advisory :** For tea estates alone, 22,206 estimations.

The demand for soil analyses by the estates, particularly for potash, was much more than in the previous year.

Botany Department

PLANT IMPROVEMENT

Production of clonal seed

A small quantity of seed was obtained this year from the polyclonal micro seed *bari* established with eight generative clones in 1966/67 (Ann. Rep. 1967-68, p. 51). The seedlings will be planted out in autumn 1972 for long term trials.

Seeds from four biclonal stocks, one from an established micro seed *bari* (stock 458) and three hand pollinated, were planted out in long term trials during 1971. From the initial observations on uniformity, growth and vigour of the seedlings, the stocks appear to be promising. Preliminary quality assessment of these stocks will be done as soon as sufficient leaf becomes available for manufacture.

The other micro seed *baris* planted in 1969 (Ann. Rep. 1968, p. 50) are expected to yield sufficient seed for trial from 1972.

Pollination programme

A series of clones of high yield and quality have been established at Tocklai for pollination purposes. Crosses will be made between selected combinations from 1972 cold weather onwards with a view to select out (i) the good combiners for clonal seed production and (ii) outstanding vegetative clones from the new recombinations. The programme also envisages production of vigorous triploids with quality, for clonal propagation.

Inter-specific hybridization

In order to verify the earlier findings based on morphological, anatomical and chemical investigations (Barua, 1965, Two and A Bud, Vol. 12, p. 13) that species hybrids involving non-tea genomes exist in cultivated tea populations, as well as to explore the possibilities of evolving new strains of tea, attempts are being made at inter-specific hybridization between tea and a few related species of *Camellia*. In the past, tea and *C. irrawadiensis* were successfully crossed at this Station and some of these hybrids are at present being used extensively in further crossings.

During 1969 flowering season, attempts were made to cross tea with the widely cultivated ornamental *C. japonica*, introduced from Japan. Out of about 30 crosses made using a tetraploid tea as female parent, only one hybrid plant was obtained out of 17 seeds from 9 fruits. The seedling flowered during 1971 cold weather. In its gross morphological characters and growth habit, the hybrid is indistinguishable from tea, except for the pink coloured reflexed petals. This successful production of a hybrid between tea and *C. japonica* and the close resemblance of the hybrid to the cultivated tea, lends support to the hypothesis that during its long history, tea might have hybridized freely under natural conditions with some of the related species like *C. japonica* growing side by side, a few of which could easily have found their way into the cultivated tea populations.

Selection of vegetative clones

About 30 bushes from biclonal and polyclonal progenies were selected during the year for rooting and long term trials.

More than 60 clones are at different stages of long term trial, out of which four clones are in the short list. Performance of this year will determine the final list of clones for release during 1972-73

Scheme for preservation of tea germplasm

The method of vegetative propagation of the tea plant was standardized and a clonal selection procedure was introduced some three decades ago. In the recent years, the use of improved clonal material for replanting, replacement and extension planting is becoming increasingly popular in N. E. India. However, apart from the 18 clones selected and released by Tocklai, the number of proven clones selected by tea estates will hardly exceed twenty. The interest shown by estates at one time in the selection of clones now appears to have been lost, although the extremely heterogenous nature of the tea populations in N.E. India offers an excellent opportunity for isolating clones of superior merit.

Many of the old seed sources (seed *baris*) and their progenies have become extinct, while a few of them are still represented here and there by old sections of tea which are getting due for uprooting. Unless adequate measures are taken, the interesting genetic material preserved by these old sections of tea, will be lost for ever.

With a view to preserve much of these valuable genetic materials, a scheme has been devised to encourage the industry to explore these old sections of tea all over N. E. India and pick up the potentially valuable bushes before they become extinct. Some of the bushes thus selected may prove to be outstanding vegetative clones while others may be useful as generative clones to be used in future crosses.

PLANT PHYSIOLOGY

Progress in the investigations of dry matter productivity has continued to be made by combining field observations with controlled environmental experiments, though some work has been curtailed by lack of facilities at Tocklai. The objective of a major part of the programme is to work out the architecture of the theoretically ideal tea plant and then to produce the nearest possible approach to this hypothetical bush. It has been calculated from gas exchange studies that such a bush could produce dry matter at the rate of some 50,000 kg/hectare/annum based on a ten hour day for 300 days per year. Of this total weight, some 12,000 kg would be in the form of plucked shoots. On existing types of tea under as near ideal conditions as are obtainable in the field, yields of 6,000 kg of made tea per hectare have been obtained from a nine month harvesting season and there seems no reason why this should not be increased as knowledge of optimum requirement of moisture and fertilisers increases.

Respiration Studies

Respiratory rates of various parts of tea plants were reported in the 1969-70 Annual Report where it was concluded that due to higher ambient temperatures in the plains of N. E. India, losses by respiration are likely to be much greater than in Kenya or most of Ceylon and South India where air temperatures are generally lower. The work has been extended to include the respiration rates of plucking shoots, mature and semi-erect leaves and complete small plants.

Balance sheets of total respiratory losses of whole plants compared to the photosynthetic gains from green tissues during daylight have been constructed and these have demonstrated that the annually increasing load of non-productive tissue on a non-increasing photosynthetic system causes a smaller proportion of dry matter productivity to be available for shoot production. This is a manifestation of senility which can be counteracted by rejuvenation as discussed in the 1971 Biennial Conference. ** The results are being submitted to Scientific Journals.

Gibberellic Acid

The differential responses of tea bushes to gibberellic acid (GA) make general recommendations for its use extremely difficult and a considerable amount of work remains to be done before this potentially useful chemical can be used to full effect. In 1970, no response to GA treatment was obtained. In 1971, two clones of differing foliage characters were treated, half the bushes of each clone having been pruned, the other half remaining unpruned. Control plots were sprayed with water and the treated plots with 25 ppm of gibberellic acid on 16th January and again on 10th May. The results are shown in Table 1.

Briefly summarised, the results have shown that clone 1, a hybrid type with high yield potential, responded well to GA when left unpruned, but not when pruned. With this clone there was also an increase in crop merely by leaving unpruned, but this was very small. In clone 2, a light leafed Assam type of average yield potential, the yield was reduced by GA both in pruned and unpruned plots. The effect of GA on unpruned tea was more depressing than on the pruned plots.

These results are not readily explicable but suggest that GA under suitable conditions will increase the yield of already vigorous tea but is unlikely to be of value in the case of weak bushes

** Two and A Bud, Vol. 18, 29-33, 1971

Table 1. Effect of Gibberellic acid spray on pruned and unpruned tea of two clones (Yield of 5 bushes in grams fresh weight)

	Clone 1 (High yield potential)		Clone 2 (Average yield potential)	
	Pruned	Unpruned	Pruned	Unpruned
Control	811	840	282	219
GA Treat	758	968	222	154
% Increase or decrease	-6.53%	+15.24%	—21.28%	—29.68%

which are probably limited in productivity by some other factor. This is likely to have been the case in the experiment as there is a marked drop in yield in the control blocks by leaving bushes unpruned and excessive leaf fall on unpruned tea indicates nutritional deficiencies. Further work on GA is obviously required before general recommendations for its use can be made.

Spacing of clones and jats

With the increasing emphasis on uprooting of old tea areas and replanting them with clones and improved seed *jats*, early return from the replanted areas to offset the cost of uprooting has assumed greater significance. Closely planted areas come into economic bearing earlier than those spaced wider. But how close tea should be planted and whether spacing should vary with the clones, bearing in mind both short and long term interest of a plantation, are questions that need early solution.

It was pointed out that spacing experiments to provide answers to these questions are impracticable (Ann. Rep. 1967-68, P. 57) and an alternative, simple approach was suggested. The method involves recording of the number and pattern of distribution of plucking points on the plucking surface of mature, widely-spaced tea bushes and working out the zone of maximum shoot density.

When the method was tried on clones and *jats* planted at different spacings, ranging from 152 cm in one direction to 61 cm in the other, the results indicated that nothing would be gained by planting any one of those clones closer than 60 cm (Ann. Rep. 1968-69, pp. 58-61). Further support to this conclusion was provided by another series of observations reported in Two and A Bud, Vol. 18(1), pp. 8-11, Jan. 1971.

A third lot of observations taken in an estate in Upper Assam, where bushes were planted in clusters of five, one in the centre and four on the four directions approximately 30 cm away from the central one, also confirms that very closely planted bushes do not develop properly or space themselves out through the death of the weaker neighbours. Details of these last observations are planned for publication.

Fertility of the soil, height of the bush frame and kind of plant are some of the known factors which determine the number of plants required per unit area of land to produce the maximum yield. Even after taking these factors and their interactions into account, all our observations indicate that planting of tea bushes closer than 60 × 60 cm would be uneconomic.

Root studies

Various observations have been made and reported from time to time on the growth of tea roots (Ann. Rep. 1960, pp. 51-52; 1963, pp. 30-34; 1966, p. 38; 1969-70; p. 46). However, the progress of our investigations in recent years on the aerial environment of tea bushes has clearly shown that application of this knowledge for increasing productivity largely depends on a fuller insight into the working of the root environment. Work on the root environment has, therefore, been initiated during the year to obtain basic information on the growth and behaviour of tea roots under laboratory and field conditions and to correlate the same, if possible, with the yield pattern of different clones. Some indications of the progress made till date are given below :

Mycorrhiza

Tunstall found that root hairs of tea were scanty, but the young white and cream-coloured portions of the root, except the root tip, were associated with a mycorrhizal fungus (Quart. J. Indian Tea Assoc., 1930, p. 75). These observations were confirmed and the fungi responsible for this infection was shown to be of the vesicular-arbuscular type: this is the group of fungi with mycelial proliferation within the host tissue producing sack like vesicles where spores are borne. There appears to be a clone to clone variation in the intensity and position of mycorrhizal infection.

In many plants mycorrhiza is known to play an important role in the nutrition of the host plant, particularly phosphate nutrition. Preliminary experiments in sterilised soil suggest this to be true in the case of the tea plant also.

Further work is continuing.

Effect of shade and nutrition on growth of tea roots

One repeat of the shade × nutrient × clone trial (Ann. Rep. 1969-70, p. 45) in Tocklai area 2A was uprooted during the 1971-72 cold weather for root observation. Each repeat of this trial was split into three parts—full sun, artificial shade and natural shade of *A. chinensis* trees, and each part was sub-divided into three strips, each receiving a different manurial treatment. Each of these nine strips in a repeat was planted out in 1959-60 with 25 clones, five each from five different light and dark leaf *jats*, the clones being selected at random. Initially each strip contained five plants of each clone planted randomly at 45 × 60 cm spacing in a row, but they were spaced out to 90 × 60 cm in 1964 removing alternate plants of the rows at the ground level. Two guard rows of clone TV 1 were planted at each end of a strip. In uprooting the repeat, 27 ×3 × 9= 729 tea bushes together with the *A. chinensis* trees of the shaded plot had to be removed.

The tea bushes were pruned normally before uprooting and the pruning weight was taken as usual. Excavation was started from one end, exposing the roots of each bush carefully and recording their spread and depth until the whole bush was excavated. The bush was then severed at the collar and the fresh weights of roots and the bush frame were taken separately. Samples of roots and tops were then dried for converting fresh weight into dry weight.

It will take yet some time to tabulate and analyse the large mass of data; some preliminary observations of interest are shown in Table 2.

The root weight was the highest in full sun and the least under bamboo screen, while weight of the top parts viz. frame, pluckings and prunings was maximum under tree shade. The ratios (1) and (2) reflect the influence of shading on the relative growth of the top and the roots. Ratio (3) shows that the fraction of economically useful growth (pluckings) per unit of frame and root increased under shade; in other words, *A. chinensis* shade trees diverted a larger fraction of the assimilates into economic yield. When pruning weight is added to the plucking weight, together representing the fraction of growth removed from the plant in course of the years, their ratios to the fraction left behind on the bush as shown in (4) maintain the same trend.

Table 2. Effect of kind of shade on the growth components of tea bushes (Mean of 243 bushes viz. 27 clones × 3 bushes × 3 treatments)

Ratios	Full sun	Bamboo screen	*A. chinensis* trees
(1) Frame wt. / Root wt.	1.14	1.28	1.68
(2) Plucking wt.* / Root wt.	2.76	3.49	4.84
(3) Plucking wt.* / Frame + root wt.	1.31	1.56	1.84
(4) Plucking + pruning wt. * / Frame + root wt.	3.33	3.76	4.49

* Total for the 10 years from 1961 to 1971

These results lead to the conclusions drawn in an earlier publication (In Physiology of Plantation Crops, pp. 307-322, 1970) that 'phenomenon of growth partition appears to be independent to some extent of total radiation and net productivity' and suggest that internal growth factors are also involved. For a fuller understanding of the mechanism of shade action in tea, a study of the causes of growth partition appears essential.

Dormancy in tea

Short day-length was shown to be the cause of winter dormancy of tea bushes in North East India and injection of gibberellic acid (GA) was observed to induce growth even during the winter months (Ann. Rep. 1968-69, pp. 61-62; 1969-70, pp. 44-45). However, some *banjhi* shoots are found on tea bushes even during the actively growing season and the proportion of *banjhis* is affected by pruning, skiffing and a few other cultural treatments. As *banjhi* formation during the summer months cannot be a day-length phenomenon, some other factors are obviously involved. It also appears from the count of *banjhi* shoots under different cultural treatments that the phenomenon of growth partition mentioned earlier in this report is linked to a degree with *banjhi* formation.

Work involving bioassay of hormones has been initiated during the year for a fuller understanding of the internal and interacting external factors responsible for *banjhi* formation during summer and complete dormancy during winter. Preliminary observation shows signinficant clone to clone variation in the lengths of the *banjhi* and growing cycles.

General

Mr. H. P. Bezbaruah, Plant Breeder, was admitted to the D. Phil. degree of the Gauhati University on his thesis entitled "Cytogenetical studies on the *Thea* and the related *Camellias*". Dr. D. N. Barua, Senior Botanist, was his supervisor.

Two junior C.S.I.R. Research Fellows joined the Department in July and are working for the D. Phil. degree of the Gauhati University under the guidance of the Senior Botanist. The problems given to them for investigation are Root Growth and Dormancy.

Entomology Department

MITES

The mite syndrome : Apart from the red spider (*Oligonychus coffeae* (Nietner)) and the scarlet mite (*Brevipalpus phoenicis* (Geijskes)), pink mite (*Acaphylla theae* (Watt) Keifer) and purple mite (*Calacarus carinatus* (Green)) together form a part of the syndrome. The distribution and abundance of these two species vary in relation to the agro-ecological conditions. On mature (30 years) China bushes in Darjeeling the purple mite population per unit area of leaf is higher than that of pink mite, and yet the latter causes more damage, sometimes insidiously. On skiffed tea in Darjeeling, populations of both species are higher at any one time of the year than on pruned tea under comparable agronomical conditions. Shade influences the numerical abundance of the two species, but not to the same extent as in red spider: shade has least influence on pink mite presumably because it inhabits the undersurface of the leaf.

Unlike in Darjeeling, the pink mite population per unit leaf area on mature tea in the Dooars is higher than that of purple mite. The seasonal fluctuation of both pink and purple mites is more conspicuous in the Dooars than in Darjeeling where the mite population stays fairly stable. The population peak of the both species is reached during July-August : thereafter the population declines. Inspite of the identical population trend, pink mite population remains relatively higher than that of the purple mite throughout the year.

In Assam, the population trends of these two species of mites vary markedly in different months. The population peak of the pink mite is reached during April to August; it happens to be June and July for the purple mite.

Of all Tocklai clones, TV 1, TV 2, TV 9 and TV 12 are apparently less resistant to pink mite, so are TV 5, TV 6 and TV 7 to purple mite. In general, Assam types of tea are more susceptible to pink mite than the chinary types, but such clear cut response is not shown by purple mite. The reasons for the varied susceptibilities and resistance of the clones to these mites are not immediately clear.

The monthly populations of pink and purple mites on different clones were correlated with the prevailing ambient temperature and previous month's rainfall. The data do not warrant a casual relationship between mite populations and these climatic factors.

Red spider damage and density : Attempts were made under laboratory conditions to see if red spider damage can be correlated to mite densities. Known densities of mites were released on China hybrid leaves to record the symptoms of damage produced. The mite densities were converted into numbers per sq cm of the upper leaf surface and correlated to the damage symptoms produced. Although good agreements were not found for every situation, the general trend was as follows :

	Average mite density/sq cm
A. Trace of bronzing on recurved margins and tip	1
B. Slight bronzing on small areas along midrib or main veins	2—3
C. Medium bronzing—more wide spread than limited area along midrib or main veins	3—4
D. Heavy bronzing—all over the leaf surface	> 4

The percentage of leaves reaching the heavy bronzing was probably most critical, though insidious damage might start at the slight bronzing stage. This method needs further testing particularly under field conditions and with further refinements it might

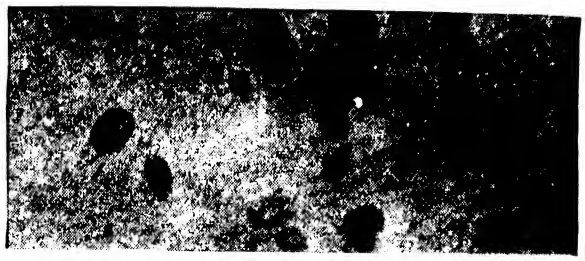


Fig. 1. A population of red spider showing eggs (spherical bodies) and active stages

be possible to develop a rapid method for assessing field populations.

STEM BORER

Life system of red borer : The incidence of red borer, *Zeuzera coffeae* Nietner, has increased of late. It damages the stems and branches of both young and mature tea, causing a reduction in the plucking points : the affected branches finally die back. The destructive caterpillar stages are passed within the branches : only the eggs and the moths stay outside. The eggs hatch out in about a week's time into first instar caterpillars, which then penetrate either into tender branches at the junction of leaf petioles or thick branches through superficial cracks and crevices. Once inside, the borers tunnel downwards eating the tissues inside, thus making the affected branches unproductive. The pupation also takes place within the branches and the moths emerge through circular holes on the stem in about 20 days time.

Fig. 2 Portion of tea branches split open to show the red borer and its tunnel

Round the year sampling of the pest indicates a bimodal peak in the emergence of the moths : these periods are March to May and August to October. However, mixed populations of caterpillars in all stages of development and even the pupae, can be sampled simultaneously at any one time. This indicates that the generations get overlapped.

Fig. 3. Emergence hole of the red borer moth showing the protruding chrysalis and the newly emerged moth resting (right)

Apart from tea, red borers infest *Albizzia odoratissima, A. chinensis, A. procera* and *Indigofera teysmanni.* It is possible the pest completes its life cycle within these shade trees and then migrates to tea. In areas with weeds the incidence of the borer in tea is nor-

mally higher than in weed free areas. Although the key factors that regulate the seasonal cycle of the borer population are not always clear, the various alternate hosts do help maintain the pest at damaging level.

Control trials against red borer : The object of these trials was to break the life cycle of the pest at any convenient stage : the moth emergence periods were considered appropriate starting points. Intensive spraying of the infested patches with Thiodan 35 E.C. (0.035%), Sumithion 50 E.C. (0.05%), Phosvel 34 E.C. (0.034%) and Anthio 25 E.C. (0.025%) during these periods prevented fresh attacks, but did not kill a significant fragment of the borer population inside the branches. When shade trees were included in the spraying schedule, the results were better, and better still with simultaneous chemical weed control. The latter spraying schedule significantly reduced the area and spread of fresh attack.

These studies clearly emphasize the need for including the spectrum of primary and secondary host plants, wherever possible, in dealing with recurring pests like red borer.

SCALE INSECT

Life system and integrated control of Scale Insect :

The scale, *Velataspis serrulata* Ganguli, is a serious pest of some clones, particularly when they are young. The scale is parasitized by the fungus, *Septobasidium* sp. In severe fungal infestations, the fluffy growth of the fungus is so thick that the scale practically remains embedded in it.

The young scale comes out of the egg within the body of the mother. Following its emergence, the young stays motionless for sometime and then starts crawling. During this mobile phase the scale gets dispersed to different parts of the plant body. Following the third moult, the scale becomes stationary and quickly pierces the bark with its sucking apparatus. Within next three hours, the scale starts secreting the wax all over its body and then becomes sessile. The scale multiplies all the year round but at a higher rate during May-June *The fungus parasitises the scale when it is still in its active stage i.e. before waxing is completed.*

Fig. 4. Scale insects-black sickle shaped bodies (extreme left) on tea stem-exposed after removal of the fungi. The fungi completely covering the scale (right)

The parasitic fungus offers some limited but useful scope for integrating natural control with chemical control, particularly when the scale-*Septobasidium* association is moderate. In such cases, a sizable scale population is killed by the fungus/fungi, and a straightforward spraying of Thiodan 35 E.C. (0.035%) or Malathion 50 E.C. (0.05%) or Rogor 40 E. C. (0.04%) brings the scale population down below the operative level.

In severe scale infestation, although the fungal growth becomes thick, the parasitic effect of the fungus/fungi does not increase proportionately with the growing scale population. A reduction in the fungal growth can however make the remaining fungusactively parasitic. Therefore, addition of a copper fungicide to reduce the fungal growth, to any of the insecticides mentioned earlier gives significant control of the scale population as stated above. However, in the absence of any precise information about the dispersal range of both the scale and fungus/fungi one cannot be precise about the lasting effect of these integrated trials.

TERMITES

Termite complex : Several termite species damage live tissues and aggravate the damage already caused by other insects and pathogens. At an advanced stage it is difficult to distinguish the damage caused by different species of termites, but a well marked differentiation exists in their mode of attack and area of activities. The species recorded for the first time on tea and the plant part area(s) they attack are shown below :

Root system	: 1.	*Coptotermes heimi* (Wasmann)
	2.	*Microtermes pakistanicus* Ahmed
	3.	*Microtermes* sp.
Bark of stem	: 4.	*Neotermes buxensis* Roonwall & Sen Sharma
Sap wood and heart wood of the stem	: 5.	*Microcerotermes* sp.
	6.	*Odontotermes feae* (Wasmann)

Fig. 5. Bushes severely damaged by live woodeating and scavenging termites

These and the two well known species *Odontotermes assamensis* Holmgren and *Odontotermes parvidens* Holmgren may not be present simultaneously on the same bush, but they are undoubtedly getting entrenched in tea. The reasons for the increased abundance of termites, old and newly recorded species alike, are not immediately clear. In some localised areas, mulching and weedicides have, apparently, accelerated termite activities. However, causal relationship are difficult to establish and further investigations are in progress.

Fig. 6. Close up view of a portion of damaged tea stem showing the termites inside

NEMATODES

Clonal susceptibility to eelworms : The susceptibilities of Tocklai clones TV 1, TV 2, TV 9, TV 10, TV 14, TV 16, TV 17 and TV 18 were ascertained by growing them in soils, artificially inoculated with a single species (*Meloidogyne incognita* Chitwood) eelworm population. The soils were sterilised to free them from other pathogens before an inoculum of eelworm was introduced. About 50 cuttings of each clone were grown in the nematode infected soil. Barring TV 9 and TV 14, the rest

resisted the nematode infestations in varying degrees, even during May to July when the nematodes multiplied fast. Some galls did develop on the roots of apparently resistant clones, but in no case did they contain enough nematodes to be of consequence.

Nematode distribution in waterlogged soils : The distribution of the root knot nematodes in waterlogged and adjacent non-waterlogged soils varied. In general, the nematode number was relatively small in waterlogged soil, but increased in samples drawn sequentially away from the waterlogged areas. This increase, however, was not always statistically significant. The low nematode population in the waterlogged spots indicated that lack of aertion due to waterlogging inhibited nematode multiplication, at least partially.

PESTICIDES

Toxicities at different concentrations of the same chemical on two diverse species : In exploratory studies, the dosage mortality responses of Ambithion 50 E. C. on the caterpillar *Parasa pastoralis* Butler and Scarlet mite *Brevipalpus phoenicis* (Geijskes) were determined using 0.20, 0.13, 0.10 and 0.067 per cent water concentrate of the active ingredient. A 90% mortality of the caterpillars at the lowest concentrate (0.067%) was obtained 72 hours after exposure, but within 24 hours at the highest concentration (0.20%).

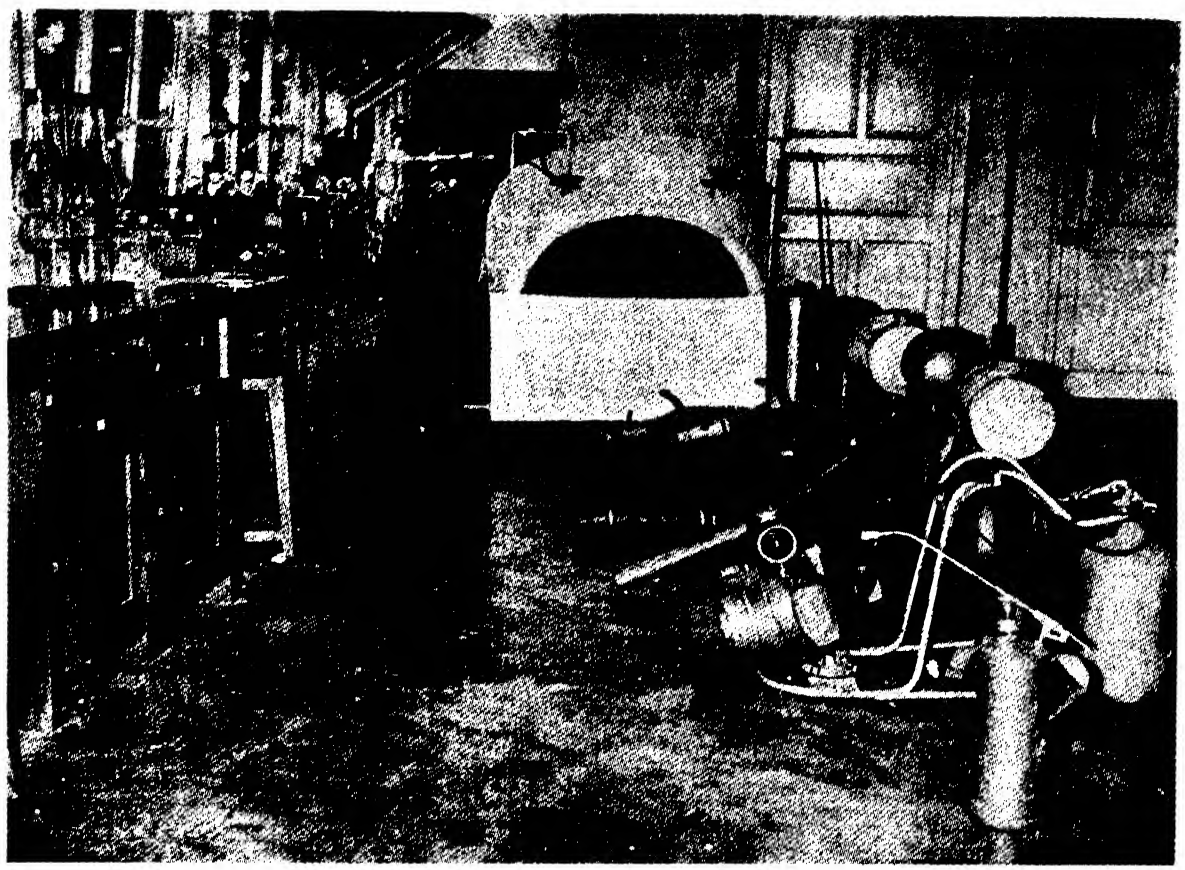


Fig. 7. A section of the entomological laboratory showing some equipment used in studying pesticides

The chemical was slow acting on the scarlet mite. A 90% mortality by the highest concentrate (0.20%) was caused following 72 hours of exposure : during this period the lowest concentrate (0.067%) resulted in about 50% mortality.

Toxic response of one species to two chemicals at varied concentrations : This study was a corollary to the previous one. Active ingredients of Sumithion 50 E.C. at 0.1, 0.07, 0.05 and 0.033 per cent water concentrates and Thiodan 35 E.C. at 0.07, 0.047, 0.035 and 0.023 per cent water concentrates were topically applied to the bunch caterpillars (*Andraca bipunctata* Wlk).

At their highest concentrates, Sumithion caused a 95% mortality within 24 hours and Thiodan in about 48 hours. Although the overall effects of the lower concentrates of both these chemicals were nearly same, Sumithion has a slightly higher edge over Thiodan.

Field trials against red spider at low toxic levels : Field applications of Trithion 20 E.C. at 0.12% concentration (standard 0.25%) and Azodrin 60 wsc at 0.25% (standard 0.50%) were made during October-November when the red spider populations were in the phase of natural decline. After four weeks, the cumulative mortality was 75% with Trithion treatment and 80% with Azodrin. At their standard dilutions, these acaricides caused nearly 95% mortality within a week. At low concentrations these acaricides acted slowly through their residual actions spreading over four weeks.

Cumulative mortality effects of pesticides at their standard concentration : To determine the cumulative mortality effects of some newly introduced pesticides, pest populations were sampled on the fourth week from the date of spraying. All were sprayed at the rate of 1.25 litre to a hectare. During intervening period between spraying and sampling the bushes were exposed to normal management practices. A set of results shown below will indicate that the chemicals were effective to a varying degree in suppressing pest population. Phosvel and Zolone appear to have both insecticidal and acaricidal properties. However, these exploratory studies preclude broad generalization.

Table 1. Cumulative toxicities of some pesticides @ 1·25 l/hectare. Percentage reduction in population over the untreated control series after four weeks

Pesticides / Pests	Red spider	Tea Helopeltis	Jassid	Looper	Scale
Acarthane	95				
Phosvel	87	50	88	84	
Zolone	76	60	70		80
Sumithion		88		90	

Nematicidal trials : The comparative long term efficacies of Nemagon 60 E.C. (37 l/ha), Lannate 90% WDC (10 kg/ha) and Temik 10 G (55 kg/ha) in suppressing root knots (*Meloidogyne* spp.) in nursery soils were assessed from their population build up upto the 70th day from the date of fumigation. The results shown in fig. 8 suggest that although the three nematicides maintained the population at steady low levels, the difference between

the pre and post treatment population was highly significant only in Nemagon treated plots. In the untreated plots the nematodes were continuously multiplying, but in the nematicide treated plots, the process was reversed in varying degrees.

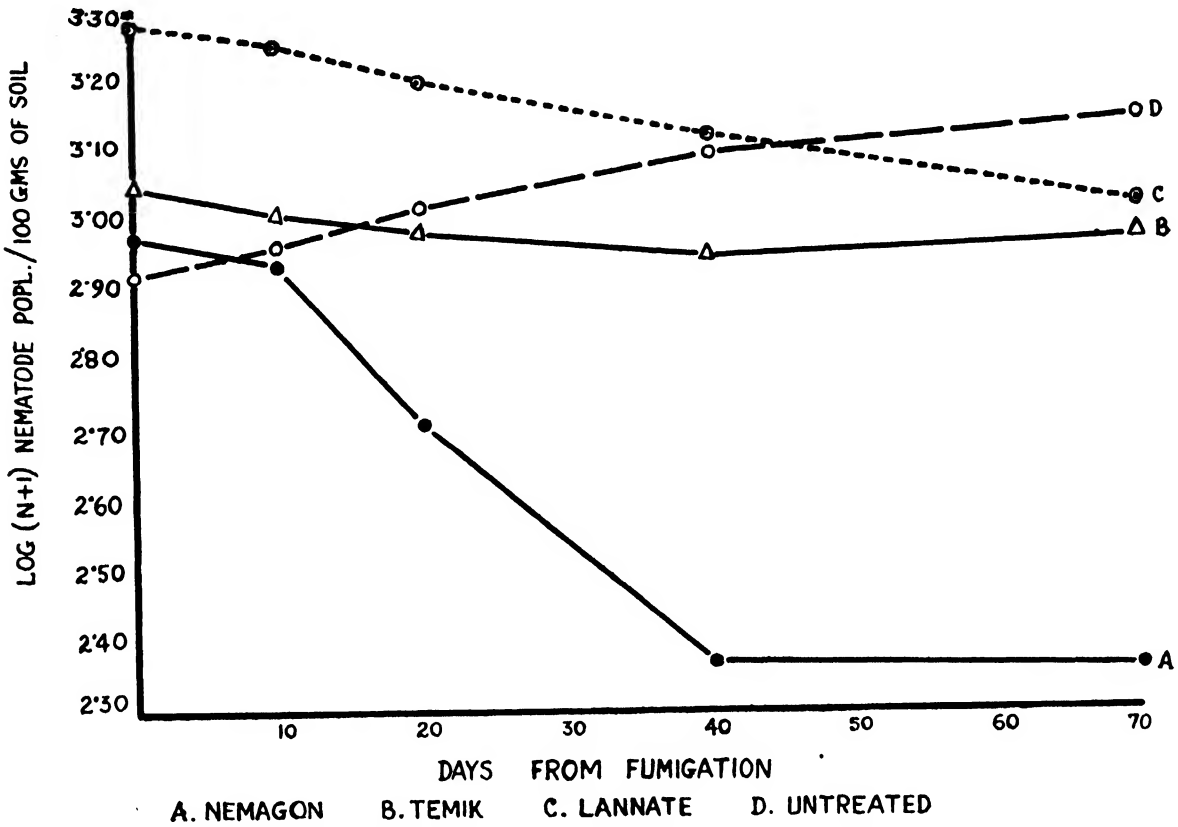


Fig. 8. Comparative efficacies of some nematicides in suppressing the population of root knot nematodes

General : The Entomologist had discussions on problems of biological control of tea pests with the Director and Entomologist-in-charge of the Commonwealth Institute of Biological Control at Bangalore : attended an International Seminar on Ecology at Delhi and UPASI Annual Scientific Conference at Conoor: Co-operated with UNESCO Special Committee on the Problems of Environment.

Mycology Department

Red Rust :

Studies on the prevalence of red rust under different conditions of tea cultivations and field management practices have revealed an interesting trend. Susceptibility of two established clones was also evaluated. Screening of new chemicals were also done during the period under report.

Red rust incidence as influenced by different methods of soil rehabilitation : These observations on red rust incidence were taken on an experiment in Borbhetta where the Agriculture Department is studying the growth and yield of hedge planted tea grown under different systems of rehabilitation of land for replanting. The Jat used is Betjan planted in 1964 at 120 cm × 90 cm spacing. The treatments are as follows :

Treatment

1. Uprooted in September 1964 and replanted within 2 months with subsoiling and deep ploughing.
2. Same as 1 above but with no subsoiling and no deep plough.
3. Uprooted in September 1963 and followed by heavy green crop for one year with subsoiling and deep plough. Planted in 1964.
4. Same as 3 above but no subsoiling and no deep plough.
5. Uprooted in October 1962 and followed by heavy green crop for 2 years with subsoiling and deep plough and planted in 1964.
6. Same as 5 above but with no subsoiling and no deep plough.

Data on relation between the soil rehabilitation and red rust incidence on replanted teas were also obtained on four of the soil rehabilitation experiments conducted by the Advisory Department on the South Bank. (25th Tocklai Conference Proceedings, page 151, 1971)

A significant decrease was recorded in red rust incidence in plots which were under green crop for one and two years before replanting.

No beneficial effect of subsoiling and deep ploughing was, however, evident. It may be that the soil of the area being sandy loam the effect, if any, may not be very marked or may take longer time to show up and may do so towards the later stage of growth of the crop.

Red rust Vs Soil compaction : Field studies had indicated that the red rust incidence was more on clayey soils which were compact. To investigate the effect of soil compaction on growth and red rust incidence a pot culture study was initiated at Borbhetta, using clones TV 1, a clone known for its susceptibility to red rust, and TV 9, a comparatively resistant one.

Wooden boxes of 30 cm×30 cm×30 cm size were used in this experiment. Ten boxes were filled with 20 kg soil and another 10 with 30 kg soil. Cuttings of the two clones were planted in October November '71. The boxes were kept randomised under overhead coir mat shade and watered whenever needed.

Soils in the plots containing 20 kg each sunk gradually by about 3-3.5 cm and did not develop much of either moss or bluegreen algal mats. The pots carrying 30 kg soil did not sink and developed excessive mosses and bluegreen algal crust. Growth observations are recorded in Table 1.

The plants in series B had a stunted appearance and the leaves were smaller.

The pots were covered and protected from inoculum during the year and the plants did not get infected by red rust. These will now be transferred to an area where no artificial protection is provided. Observation will be continued for red rust infection.

Table 1. Effect of soil packing on growth of clonal plants

Soil per pot of 30×30×30 cm	Clone	Average No. of plants living out of 20	Average height/plant in cm	Average No. of leaves/plant
A. 20 kg	TV 1	8	13 cm	6
	TV 9	16	16.4 cm	9
B. 30 kg	TV 1	7	8.7 cm	3.2
	TV 9	15	8 cm	4.8

From Table 1 it appears that the growth became stunted when the soil compaction increased. Both the clones reacted almost in a similar way towards the increased compaction except for the fact that the mortality was higher with TV 1 as compared with TV 9.

Red rust in relation to Spacing, Clone and Nitrogen : Observations on the incidence of the disease in relation to spacing, clone and nitrogen were made. In an area at Borbhetta where two different clones with four different spacing and three levels of nitrogen since 1966 are being studied by the Agriculture Department, the red rust incidence was observed and the results are reported below.

The factors involved are :

1. Spacing — No. of bushes/ha
   - S_1 — 120 cm × 90 cm — 9259
   - S_2 — 120 cm × 45 cm — 18520
   - S_3 — 120 cm × 30 cm — 27780
   - S_4 — 120 cm × 22.5 cm — 37040
2. **Clone**
   - C_1 — TV 9
   - C_2 — TV 1
3. **Level of Nitrogen**
   - N_1 — 100 kg N/ha
   - N_2 — 200 kg N/ha
   - N_3 — 300 kg N/ha (observation was not taken due to two missing plots)

The treatments were randomized and replicated and the number of bushes per plot varied from 50 to 200 depending on the type of spacing. The red rust incidence was recorded since 1967.

The two clones varied significantly in their susceptibility—Clone TV1 is significantly more susceptible to red rust infection than Clone TV9. There was an indication (though not significant) that the closer the spacing, the lesser is the degree of incidence of the disease. Nitrogen manuring above 100 kg/ha had no significant effect on red rust incidence.

Screening of pesticides : Two new chemicals (polyram combi and Panacide) were tested for their efficacy in controlling red rust in the field during the heavy sporulating period of the alga (May-July). The chemicals tested were found to be inferior to the standard copper formulations recommended for the control of the disease.

Copper spraying at lower dilutions : In two different studies, a copper fungicide was applied with hand operated sprayer at the standard (0.25%) as well as half the concentration (0.125%) with and without sticker (Tenac) to the bushes showing infection during the fruiting period. Altogether four rounds were given at monthly intervals from May to August. It has been observed that all the treatments have given appreciable reduction of the disease. The results are very interesting. Possibility of controlling red rust significantly with only half the amount of copper fungicides is very tempting for its economy. Further studies are in progress.

Branch canker

Thorny stem blight : The degree of development of the disease in the Darjeeling Advisory Department NPK experiment was recorded. It has been observed that all the plots receiving manurial treatments showed significantly lesser infection of the disease than the plots receiving no manure.

NPK Manuring Vs. Poria branch canker : Observations on incidence of *Poria* were made in experiment No. B 43 at Borbhetta. In this experiment 2:1:1 NPK mixture has been applied at 0, 45, 90, 135, 180 and 225 kg nitrogen per hectare since 1930, when the tea was eight years old. Levels of nitrogen manuring had no significant effect on the incidence of *Poria*.

Black Rot

Chemical control of black rot by spraying a copper fungicide (both copper oxide and oxychlorides) is an economic proposition (vide Annual Report 1969-70).

For the effective chemical control of black rot, application of a copper fungicide at 4.5 kg (0.25% concentration, when applied with a hand operated sprayer) or at 2.5 kg/ha (when done with a power sprayer) in two rounds at fortnightly interval is recommended. This is usually followed by one round of spot spraying of the diseased bushes only. Here, the time of applying the first two rounds is very crucial. It is done when the fungi concerned begin to regrow from the overwintering resting stage (Sclerotia) with the onset of rains in April. The effect of spraying two rounds of copper fungicide at the time of the development of the disease on yield return and also the effect of giving more rounds of copper during this period were assessed this year, in a trial which was initiated in the North Bank in the year 1968. The plots were efficiently sprayed with a standard copper oxychloride (Blitox) in two rounds at fortnightly interval in May—June during the first two seasons (1968 and 1969). No fungicidal spraying was done in 1970 and 1971. The total degree of incidence of black rot per plot of 40 bushes are shown in Table 2 the degree of incidence being marked in the scale from 0 to 4 depending on whether the degree of severity of attack was absent, slight, medium, severe, or very severe.

Table 2. Effect of Copper fungicide spray at different rates on black rot incidence.

Treatments	Disease infection rate							
	1968		1969		1970		1971	
Blitox rate with sprayer	Score on 40 bushes	as % of control	Score on 40 bushes	as % of control	Score on 40 bushes	as % of control	Score on 40 bushes	as % of control
@ 4.5 kg/ha by Knapsack	12	11	9	8	13	15	25	32
@ 2.5 kg/ha by Fontan	6	6	5	4	11	13	32	42
@ 4.5 kg/ha by Knapsack	8	8	4	3	11	12	25	32
No Spray- Control	107	100	115	100	83	100	77	100
C. D. at 5% level	12.2		8.4		11.2		19.6	

The treated plots are still showing significantly lesser infection than the untreated plots, though the spraying was stopped in 1969. The disease is, however, on the increase in the sprayed plots since 1970, despite the declining trend noticed in the unsprayed plots.

The yield of green leaf obtained for each treatment during the four year period is given in Table 3.

Table 3. Green leaf in kg/plot. Total of 4 years 1968-71

Treatment	Round up Green leaf	% Gain
Blitox 0.25% (approximately 4.5 kg/ha) with Knapsack sprayer	853	10.5
Blitox 2.5 kg/ha with Fontan sprayer	849	9.9
Blitox 4.5 kg/ha with Fontan sprayer	848	9.8
Control	772	

The table shows that a substantial gain in yield is possible by efficiently applying the right chemical at the appropriate time. It is intended to keep this area under observation till the disease development in the sprayed plots is at par with the disease incidence in the untreated plots, if it happens. This will indicate the after effect of spraying against black rot.

Increased number of spray rounds in relation to disease control : The effect of increasing the number of spraying rounds were studied in two different districts—one in a garden on the South Bank and the other in another garden on the North Bank.

The treatments were started in 1971 and are as follows :

Treatments

T_1- Blitox 0.25% in 2 rounds at fortnightly interval
T_2 - ,, ,, 3 ,, ,, ,, ,,
T_3 - ,, ,, 4 ,, ,, ,, ,,
T_4- Blitox 0.25% in 2 rounds at fortnightly interval and one more round a month later.
T_5- Blitox 0.25% in 2 rounds at monthly interval
T_6- Control (Unsprayed).

The results are shown in Table 4.

Table 4. Total black rot incidence

Treatments	Experiment I	Experiment II
T_1 - Blitox 0.25% in 2 rounds at fortnightly interval	20.0	22.2
T_2 - Blitox 0.25% in 3 rounds at fortnightly interval	14.5	19.6
T_3 - Blitox 0.25% in 4 rounds at fortnightly interval	9.8	14.4
T_4 - Blitox 0.25% in 2 rounds at fortnightly interval and one more round a month later	9.8	13.0
T_5 - Blitox 0.25% in 2 rounds at monthly interval	17.8	16.4
T_6 - Control (unsprayed)	68.8	40.0
C. D. at 5 % level	8.2	8.5
C. V.%	23.1	30.8

All the treatments have given significant control. The economy of giving one more round following two rounds at fortnightly interval, without affecting the beneficial effect is quite evident.

This experiment will be repeated in different conditions for confirmation.

Primary root rot disease

Purple root rot : This experiment on the control of purple root rot was started in 1966. Observation on the incidence of disease is continued. No death has so far been recorded on the experimental plots. Development of fungal felts at the collar region was however noticed on some plants. Observations will be continued in 1972-73 season also. The causal organism *Helicobasidium compactum* Boedin., is diagnosed and confirmed by the Commonwealth Mycological Institute, England.

Aerobiology

Studies on the effect of climatic conditions on spore production and discharge pattern have been continued for the 2nd year in succession using the Hirst Spore trap. The results could not be obtained after the pressure pump failed during the month of September. Findings upto August are in conformity with the results obtained in the previous year. Black rot spores were abundantly dispersed on days having relative humidity between 85% and 93%, rainfall over 85 mm, temperature above 33°C and low (0-3.5) sunshine hours. Red rust spores were abundant, on days when there was no rainfall, humidity was around 80% and sunshine hours over 6 hr. Spore numbers decreased on the following day.

Red rust spores were found in the air till the 14th September and those of black rot till 3rd September.

Biochemistry Department

Testing the correlation of Four important chemical constituents with organoleptic rating for four Tocklai released clones/jats

Statistical correlation between four important chemical constituents and organoleptic tests, was derived earlier from C_5 experiments (vide Annual Report 1966, page 89-91). For tasting the validity of this equation for three clones TV-11, TV-12, TV-14 and one stock no. 450, chemical determinations were made for total oxygen uptake (in green leaf); theaflavin (in made tea); (—)—epicatechin gallate (in made tea), and theogallin (in made tea). The data have been sent to the Statistician for testing the applicability of the correlation observed earlier to these plant materials. Further analysis of other clones and jats is in progress.

Biochemical Differentiation of Clones and Jats

The differentiation of four clones was reported in the annual report 1969-70 on the basic of enzyme activity (QO_2/mg/ml/hr) and total oxygen uptake (mg/ml/2 hours) of green leaf and condensed polyphenols (TFs + TRs) of the corresponding made teas. However, a small variation in the manufacture alters the contents of theaflavins and thearubigins of tea even in the same source of green leaf. Analysis of the green leaf alone rather than made tea could be a better indication for differentiating clones. Consequently total oxygen uptake and total oxidisable matters of green leaf were determined for clones TV-11, TV-12, TV-14 and Stock 450. Teas made from these sources were tasted by the panels of tasters at Tocklai and London.

The quality of tea improved with the increase of Total oxygen uptake and total oxidisable matters of the corresponding green leaf. In biochemical ranking the clones TV-11 and TV-12 were almost similar whereas TV-14 was superior to either of them. The stock 450 was the poorest.

Tasters were also of the opinion that the overall quality of clones TV-14 and TV-12 was nearly the same and TV-11 was very slightly different from them. But stock 450 was the poorest of them all. The difference between the taster's opinion and that of biochemical differentiation may be attributable to the difference of testing materials in green leaf for biochemical differentiation and made tea for organoleptic tests.

Regulation of Theaflavins/Thearubigins during Manufacture

The presence of two principal colouring matters theaflavins and thearubigins in definite proportions is largely responsible for the quality of tea.

Experiments were conducted at Tocklai miniature factory to regulate the proportions of theaflavins and thearubigins during the process of manufacture by a suitable chemical treatment. Green leaf samples weighing 1 kg and $7\frac{1}{2}$ kg were manufactured by Roller/CTC method. The chemical was added to either green leaf, withered leaf or fermented tea leaf particles. The control and the treated teas were analysed for theaflavins and thearubigins and tasted by the Tocklai taster and the tasting panels of Calcutta and London. It was found that the valuation of treated teas was higher by 25 to 50 paise per kg of tea compared to those of the control, the cost of chemical being one paise only.

Further, the deterioration in quality due to prolonged fermentation could be reduced to 50 per cent by this chemical treatment of the fermented leaf particles. This experiment will be conducted commercially in 1972.

Constant Colour Theaflavins from Tea Fluff

Attempts were made to improve the quality of tea by spraying constant colour theaflavins extracted from tea-fluff after fixing the thearubigins at a suitable pH. A preliminary experiment was conducted by using different concentrations of the extracted theaflavins. The results were promising. Further work will be undertaken in 1972.

Ambient Drying Temperature for Quality Tea and its Effect on Keeping Quality of Tea

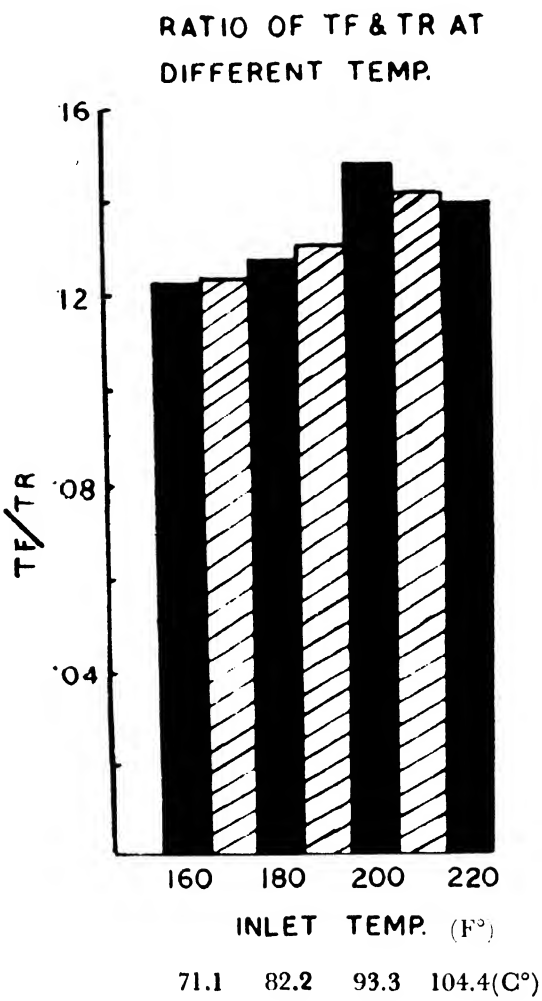
The dual objectives of the present study are to find out temperature or temperatures of the air used for drying the fermented leaf particles (CTC) at which (a) the chemical constituents present in the tea leaf can be best utilized for the production of good quality tea judged both chemically and organoleptically and (b) the keeping quality of tea (stored at room temperatures) improved.

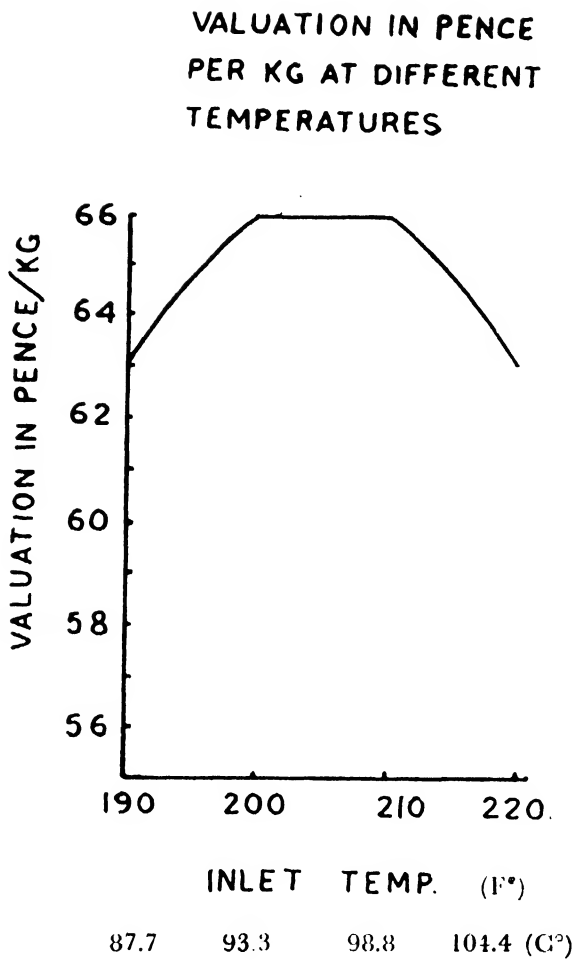
15 kg (TV-2) of green leaf was withered to approximately 75 per cent for a Roller/CTC method of manufacture. It was then rolled for half-an-hour prior to C.T.C., followed by fermentation for 1 hr - 40 min. from the start of rolling. It was then dried in 4 repeats using the following different inlet temperatures : 71.1°C, 76.6°C, 82.2°C, 87.7°C, 93.3°C, 98.8°C and 104.4°C.

The freshly made teas (drier mouth sample) were analysed for theaflavins, thearubigins, enzyme activity, theogallin, (—)—epigallocatechin gallate, (—)—epicatechin gallate & moisture and were submitted for tasting. After storage for 15 weeks at room temperatures varying between 13.9°C to 35°C, the teas were analysed and tasted again, followed by periodical analyses upto the time of 'going off' of the teas.

Teas dried at the higher inlet temperature of 93.3°C and 98.8°C were found to be the best in respect of the amounts and ratio of theaflavins and thearubigins producing the maximum brightness, colour and strength. The ratio of TF/TR was minimum in the teas dried at lower temperatures of 71.1°C—87.7°C and the quality of the teas became poor. At lower inlet temperatures (71.1°C—87.7°C), the enzyme deactivates slowly and the fermentation proceeds further, thereby increasing the content of the thearubigins. When the inlet temperature was raised to 104.4°C, the ratio of TF/TR again increased due to an increase in thearubigins this time caused by overfiring. These findings were also corroborated by the tasters.

On analysing the teas after storage for 15 weeks, similar effect of drying temperature was again obtained although the contents of theaflavins, thearubigins and enzyme were found to decrease (during storage) in every case. Teas after storage were assigned a lower value than fresh teas. However, the one dried at 93.3°C to 98.8°C still received the highest value. Two graphs are included, one for TF/TR ratio and the other for price index.





Miscellaneous Experiments

Leaf Temperature Determination during Drying

Determination of temperature of leaf particles at various stages of drying poses a problem. A chemical method has been almost perfected. Using this method an attempt is being made to correlate the moisture content with leaf particle temperature at different intervals in the process of drying and at different inlet temperatures (71.1°C—104.4°C). Preliminary results are promising. Further work is continuing.

Analysis of Samples

Eighty-nine and forty-four tea samples from Research Engineering & Development Department, Tea Tasting Department and various tea estates were analysed for theaflavins and thearubigins and moisture content respectively.

Moisture Meters

Seventeen Infra-red moisture meters (Kaybee & N-Foss types) from different tea gardens were calibrated during the year.

Manufacturing Advisory & Tea Tasting Department

EXPERIMENTS AT TOCKLAI

Quality vis-a-vis Pruning and Skiffing : An experiment was carried out to see the quality of teas made from pruned, medium skiffed and unpruned plots, using the C.T.C. method of manufacture and leaf from clone TV. 1.

The made tea samples were then tasted by the Tocklai Tasters blindly and valuations were given for pruned, medium skiffed and unpruned teas, which are shown in the graph below and in Table 1.

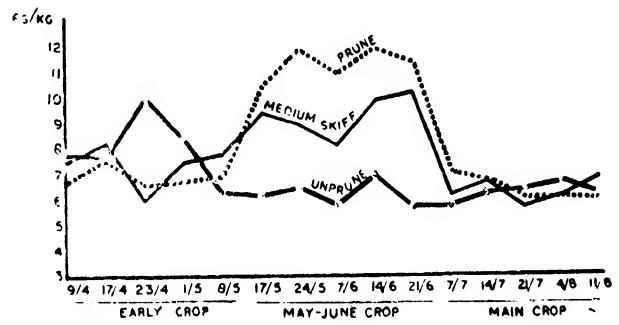


Table 1. Valuations in Rupees per Kilogram

	April-May Crop	May-June Crop	July-August Crop
Pruned	6.90	11.40	6.40
Medium Skiffed	7.40	9.40	6.40
Unpruned	8.00	6.30	6.30

The results show that good quality C. T. C. teas are made in the early part of the year with leaf from unpruned bushes. It was also observed that in May-June crop, leaf from pruned bushes was much superior compared to medium skiffed and unpruned whereas in rains crop there was hardly any difference between the treatments.

In conformity with the results published in the Ann. Rep. for 1969-70 page 66, the teas made from pruned clonal bushes were again found to be distinctly superior to the teas made from unpruned and skiffed bushes. On the contrary, from this experiment it was observed that good quality was also detected in teas made from unpruned bushes early in the year when leaf from pruned, deep skiffed and medium skiffed bushes was not available.

Dual Manufacture : An experiment was carried out with 4 kg leaf samples of clones TV2, TV4, TV6 and TV18 to find out the performance of TV clones on dual manufacture.

Fresh leaf withered down to 70% which gave about 31% recovery from withered leaf to made tea, was rolled for 30 minutes in two 1 kg Pizey rollers. After 30 minutes roll with sufficient pressure to express juice on the table, the leaves were sifted with sieve No.6 and 10% fines were extracted for making orthodox tea.

The orthodox fines were fermented for three hours including rolling time and the remaining samples were passed twice through C.T.C.s and fermented one hour and forty minutes including rolling time.

Orthodox fines were dried for 55 minutes with an inlet temperature of 75°C(200°F) while C. T. C. samples were dried for 30 minutes at the same inlet temperature.

Thereafter, orthodox bulk grade was prepared by passing the mal through sieve No. 8 and over No. 36. The C. T. C. bulk grade was prepared by passing through No. 14 and over sieve No. 36. Samples were tasted by the Tocklai Tasters in codes and the valuations (average of three repeats) for different seasons obtained by different clones, are given in Table 2.

Table 2. Valuations in Rupees per Kilogram

Clones	Code No.	Valuations 2nd flush	Valuations Rains	Valuations Autumn
TV2	Orthodox	30.00	15.00	20.00
	C. T. C.	8.50	7.50	8.00
TV4	Orthodox	25.00	12.00	15.00
	C. T. C.	7.00	6.00	6.50
TV6	Orthodox	40.00	18.00	25.00
	C. T. C.	8.00	7.00	7.50
TV8	Orthodox	10.00	8.00	8.00
	C. T. C.	8.00	6.00	6.50
TV18	Orthodox	10.00	8.00	9.00
	C. T. C.	7.80	7.00	7.50

From the above it seems that TV2, TV4 and TV6 will be suitable for dual, orthodox and C. T. C. manufactures, whereas TV8 and TV18 will be suitable for C.T.C. manufacture only, as these two clones hardly have any tip; also their cup characters in orthodox manufacture are rather poor.

It is proposed to try out all the Tocklai released clones one by one, to find out their performances on dual manufacture.

Legg-cut manufacture : It is observed in Legg-cut manufacture that two cuts predominantly gives Fannings and Dust grades. After the first cut, the leaf from the first Legg-cutter is removed and fed at right angles to the second cutter. This enables one to obtain evenly sized cubes of fresh leaf. Breaking operation in the dry leaf stage is also minimised thereby. The widths of the first and second cuts should normally be between 1/36" and 1/48". These cuts mainly depend on size of the grade required. The widths of the cuts may not remain the same throughout the season as it is likely that during heavy flushes the size of cut may have to be increased to cope with the crop.

Botany Department :

Selection of clones : During the year leaf samples of 13 clones from a long term clonal selection trial each of one kilogram, were manufactured in the Miniature Factory both by orthodox and C.T.C. methods for evaluation of cup characters and yield potentiality. These teas were tasted 20 times at Tocklai and 14 times by the Calcutta panel and 16 times by the London panel of tasters. From this experiment three clones appeared to be of promising quality.

Selection of flavoury clones : Six clones together with one control were manufactured in the Miniature Factory for evaluation by the Tocklai Taster. From this experiment three clones were found to possess good flavour. On the contrary another lot of ten clones from Indo-China and China hybrid varieties along with two standards were manufactured and tasted by both Calcutta and Tocklai tasters. The results showed that four clones were promising in cup characters.

Grafting experiment : The experiment on the influence of root stock on quality of grafted scions was further continued during the year. Nineteen

miniature samples were manufactured in the Miniature Factory and tasted on several occasions. Although the tasting indicated slight influence of root-stock on quality of leaf from the grafted scions, the difference was not statistically significant.

Effect of pruning time on quality : During the year, four different pruning treatments were carried out. The treatments consisted of pruning at different periods of the year and one was kept unpruned. The pruned was let up by 10 cm in July and then plucked after fifteen days. Tasting result showed that superior teas may be obtained by letting up normal pruned tea by 10 cm in July and then plucked after fifteen days.

Biochemistry Department :

Analysis of statistically important chemical constituents of diffffferent jats/clones of N. E. India Plains tea : 108 samples were manufactured in the Miniature Factory by orthodox and C.T.C. methods and tasted by Tocklai, Calcutta and London panels of tasters. The analytical reports were sent to the Statistician to test the validity of the equation based on the C5 experiment.

'Going off' of tea : 131 samples were manufactured during the year and tasted by the Tocklai and London panels of tasters. Teas were dried at 160 and 220°F and stored at room temperature of 96°F and tasted periodically. The experiment is being continued.

Study of effect of acidity on quality of tea : 161 samples were manufactured in the miniature factory by C.T.C. method and tasted by Tocklai and London panels of tasters. The experiment is carried on further.

Engineering Research & Development Department :

During the year, 925 samples were manufactured both by orthodox and C.T.C. methods and tasted by the Tocklai, Calcutta and London tasting panels. Among these, experimental samples from Disc Roller, BLC cutter attachment and Continuous Fermenting Machine trial were included. It was observed that the liquor characters of the tea samples from the conventional prototype Disc Roller and BLC cutter attachment gradually improved throughout the season.

Clonal Proving Station, Darjeeling : During the season 9 clones were manufactured in the Miniature Factory at Darjeeling and 249 samples were received and reported on. No definite results could be obtained during the year because the clonal bushes were very young. It is proposed to manufacture leaf from the same bushes with statistical lay-out.

TESTING OF COMMERCIAL PRODUCTS

Sodium Hexametaphosphate or Colgan : This is a chemical sample supplied by Messers Williamson Magor & Co. Ltd., to find out its effectiveness in treating water containing excessive iron. 102 samples were manufactured by C.T.C. method in the Miniature Factory and tasted at Tocklai. The samples tasted bitter. Hence the chemical was not considered suitable for use as an antiprecipitating agent for water containing excessive iron.

Plastic Rungbowls : Plastic rungbowls supplied by Messers Calcutta Engineering Stores Co., 9, Clive Row, Calcutta were tested and found suitable for use in the tea industry. However, they were a little weaker compared to the normal plastic rungbowls used in tea factories.

Idet- 5L- SP-NF : Idet, a liquid detergent received from Messers Industrial Products Sales Division, Sarabhai Sons Private Ltd., c/o Swastik Oil Mills, 67, Dr. Suresh Sarker Road, Calcutta-14, was tested and found suitable for use in tea factories for cleaning of fermenting surface and green leaf processing machines.

Sackfilm H-Polymer Paper : A sample of Sackfilm H. Polymer was tested to find out its suitability as a packaging material. The material imparted no taint to the made tea and was found suitable for packing purpose.

Corrugated Cardboard Cartons for packing of tea : In continuation to the experiment carried out in 1970-71, further experiments with stronger corrugated cardboard boxes were carried out. Teas in these cardboard boxes were considered slightly superior by the Tocklai Taster while the London panel found no difference compared to the normal plywood tea chests.

The cardboard boxes still tended to bulge which gradually increased with the length of storage period.

However these boxes, for packing of tea have a great promise but as it appears, considerable attention would be necessary to make the boxes stronger to prevent the bulging tendency.

TEA TASTING AND ESTATE VISITS

Tea Tasting : During the season 3,560 experimental samples from Tocklai, 12,393 samples from estates for advising on manufacture, and 4,732 clonal samples from estates were tasted. Besides this, a large number of samples were also tasted during visits to the factories.

Estate visits and tasting sessions : The Manufacturing Adviser & Tea Taster visited 60 factories in Assam, Cachar, Dooars and Darjeeling for advising on manufacture and attended seven tasting sessions. The Tea Taster visited 95 factories for the same purpose.

Lectures : Two lecture courses on Factory Management together with demonstrations were organised by the Manufacturing Adviser & Tea Taster in collaboration with the Engineering Research & Development Department and Biochemistry Department.

Meetings : The Manufacturing Adviser & Tea Taster arranged two group discussions on Tea Manufacture at Deohall T. E. at the request of the General Manager, Warren Tea Group. The Senior Research Engineer also took part in this group discussion. The Manufacturing Adviser & Tea Taster and Tea Taster also attended the conference of Workshop on Sensory Evaluation of Food Technology and Research Institute in Mysore in the month of July.

Engineering Research & Development Department

RESEARCH & EXPERIMENT

ROLLING

Continuous Green Leaf Processing Machines

1. Disc Type Continuous Roller : The commercial prototype 122 cm (48") Disc Roller made by Port Engineering Works with standardised components excepting the battens was installed at Tocklai early in the 1971 season. Preliminary trials were made at Tocklai with various sets of battens at two different speeds, 7 and $7\frac{1}{2}$ r.p.m. of the disc against conventional orthodox roller. Samples were tasted by Tocklai, Calcutta and London panel of tasters. The average comparative scores based on their reports are tabulated below :—

Table 1. Tocklai, Calcutta and London Tasters' valuations. Disc Roller Vs. Conventional Roller

Date of manufacture	Speed of the Disc. (r. p. m.)	Valuations of Tasters					
		Tocklai (Rs.)		Calcutta (Rs.)		London (Pence)	
		Disc roller	Conventional roller roller	Disc roller	Conventional roller	Disc roller	Conventional roller
6.7.71	$7\frac{1}{2}$	5.64	6.48	6.67	5.46	57.7	57.7
13.7.71	$7\frac{1}{2}$	5.67	6.83	·	—	53.7	52.5
20.7.71	$7\frac{1}{2}$	5.33	6.07	6.75	7.45	47.5	52.9
27.7.71	$7\frac{1}{2}$	5.79	6.52	6.57	7.63	49.4	52.5
3.8.71	$7\frac{1}{2}$	6.11	5.98	6.43	7.60	52.6	48.4
24.8.71	$7\frac{1}{2}$	6.22	6.15	7.23	7.87	57.3	46.4
3.8.71	7	5.98	5.98	6.65	7.60	51.2	48.4
10.8.71	7	5.34	6.30	6.59	7.63	41.9	47.5
24.8.71	7	5.42	6.15	7.54	7.87	51.6	46.4
31.8.71	7	6.16	6.96	6.91	7.93	49.5	50.7
7.9.71	7	5.73	6.59	7.55	7.75	—	—
14.9.71	7	6.17	6.59	6.72	7.16	—	—
21.9.71	7	6.00	6.65	6.27	6.66	—	—

The general remarks of the tasters in most cases was that although the Disc Roller samples have good bloom, the leaf appearance is poor.

The machine at this stage was shifted temporarily to Heeleakah Tea Factory during early November for commercial trials against conventional rollers. During the course of these trials in November and December various types of battens were used and 71 comparative sets of samples were collected. Of these in 33 occasions, Tocklai Tasters preferred the Disc Roller samples. On a number of occasions, the disc roller was tried as a second roller for coarse leaf after extraction of first fines from a 30 min conventional roll. Taster's opinion on the leaf rolled in this manner is as follows:

"The sample is blackish, fairly well twisted with fair amount of golden tip".

At this stage of development of the disc roller, the fine leaf produced by it after two passes through this machine is acceptable, but the coarse leaf required

further processing. Keeping this in view, further trials of the machine with different sets of battens, with different speeds and with springs of greater stiffness were started at Tocklai early in this '72 season for improving the leaf style and standardising the commercial machine. The results of the limited number of trials so far conducted with a stiffer spring are encouraging. According to Tocklai Tea Taster, the fines produced this way are well twisted and contain good amount of golden tips and the coarse is fairly well twisted with some tip.

During the commercial trials the output of this machine was found to be 1640 kg withered leaf per hour for the 1st pass with the disc runing at $7\frac{1}{2}$ r.p.m. and the feed worm at 22 r.p.m. At these speeds the power requirement was found to be well within 10 H.P.

2. **Barbora Continuous Leaf Conditioner :** Of the three commercial units of the 38 cm (15") Barbora Continuous Leaf Conditioners, two units were operating satisfactorily throughout the season at Powai T.E. in competition with two standard rotorvanes in conjunction with C.T.C. machines. Reports from the estate manager indicated that teas from the B.L.C/C.T.C. method of manufacture are in no way inferior to the standard rotorvane/ C.T.C. manufacture whilst in most instances the B.L.C/ C.T.C. method produced very much brighter and brisker teas compared to the standard.

Design details of this machine for commercial production by the Association's licensees have been finalised now. In order to improve the mechanical strength of the barrel, it has been decided to replace the brass lined C. I. barrel with a brass lined barrel of mild steel construction.

3. **Leaf Sizer Attachment :** As a result of the previous years successful trials with the cutter attachment tried out at Tocklai in conjunction with a 20.4 cm (8") prototype Leaf Conditioner, further trials were conducted with commercial machines last year. A 38 cm (15") Leaf Sizer Attachment was fabricated at Tocklai and tried out at Kakajan Tea Factory against rotorvane/ C.T.C. manufacture. The fitment had to be modified slightly to cope with different types of end plates used with the rotorvanes there. The results so far obtained from the Tocklai Taster's assessment indicated that teas produced from this machine were generally comparable to Kakajan's normal C.T.C. teas. The design of the attachment is being streamlined to improve its performance and reduce the total power requirement for the machine fitted with this attachment. Necessary modifications in the arrangement of one of the rotorvanes were already done to adapt itself to the new design. Further commercial trials will be conducted this year with attention to the leaf appearance, output and liquor characters of the teas, made with this unit.

Fermentation

Tocklai Continuous Fermenting Machine : The 152 cm (5'-0") Tocklai Continuous Fermenting Machine was shifted to and installed at Beesakopie Factory in the Doom Dooma District. The department conducted preliminary trials there against that factory's W.M. type of trough fermentation. the comparative test data on the teas are given in table 2.

Further trials were conducted at Beesakopie Factory under the guidance of Dr. John Hewitson, a Brooke Bond Research Chemist, from East Africa and Blounts Court, England. A preliminary report received from him is reproduced below :—

"Preliminary Report on the Tocklai Continuous Fermenting Machine :

"Experiments were carried out at Beesakopie Factory, Doom Dooma, Assam, during June and July 1971 to compare the Tocklai Continuous Fermenting Machine with the normal Williamson Magor Trough Fermenting system. Ex-drier teas were collected and samples were presented to Tasters. Each pair of samples was representative of a full day's production.

"When tasted in Assam, in 8 out of 12 pairs the Williamson Magor Trough fermented tea was preferred to the tea from the Tocklai Fermenting Machine.

"Samples from two weeks operation were tasted by the Saleroom Panel at Blounts Court. Twelve pairs of teas were tasted twice by three tasters and trough fermented teas were preferred for taste on 51 occasions out of 72 and on 52 out of 72 for appearance. There was a mean difference in valuation of $2\frac{1}{2}$ p/kg in favour of the trough fermented tea during the 1st week and of 1 p/kg during the second week when a different way of operating the machine was used.

Table 2 Assessment and analysis of comparative samples fermented in the Continuous Fermenting Machine (CFM) and Fermenting Trough at Beesakopie T. E.

Date of manufacture	Sample No.	Method of Fermentation	TF%	TR%	Biochemists' Remarks	Tocklai Tea Taster's Remarks
25.5.71	A_1	C. F. M.	1.40	13.30	Trough better than C. F. M.	C. F. M. preferred
	B_1	Trough	1.66	13.41		
	A_2	C. F. M.	1.48	12.26	Trough better than C. F. M.	Trough preferred
	B_2	Trough	1.74	12.58		
	A_1	C. F. M.	1.99	12.34	Almost similar	C. F. M. preferred
	B_1	Trough	2.09	12.69		
	A_2	C. F. M.	1.84	12.42	Trough better than C. F. M.	Trough vastly superior to C.F.M. samples.
	B_2	Trough	1.98	11.86		
	A_3	C. F. M.	1.95	12.87	C.F.M. better than trough	C. F. M. much superior to trough
	B_3	Trough	1.84	13.09		

"The temperature of the leaf always increased during fermentation from about 30°C ex-C.T.C. to 35-40°C at the end of 50 minutes fermentation whereas in the trough the temperature fell to 26-28°C during fermentation. No facility exists for measuring or controlling the temperature during fermentation except by washing the air with water during recirculation. The machine was originally designed for use with a refrigeration plant but Tocklai have apparently abandoned this.

"A full report is in preparation but the present impression is that the Tocklai Machine is not a good basis for further development and a completely new design should be considered if and when continuous system is required".

The above report although preliminary in nature, indicates the areas where further improvement could be achieved. Without Biochemical data, the report from the Blount's Court Scientist could not be assessed objectively. Tocklai's thinking on the methods of cooling to be used in connection with this machine and its economics have been set out by the Senior Research Engineer in his communication to the Development Panel and the Engineering Sub-Committee from time to time.

It is however, gratifying to note that the report has not been found to be acceptable in its totality by the management of Beesakopie. The Superintendent has informed the department that "as a

basis for further development the machine has potential". Also from the trials conducted by the department earlier, it appears that the Continuous Fermenting Machine is almost equal to, if not better than the known standard methods of fermentation.

The manufacturing licence for commercial manufacture of this machine has been awarded to M/s. S. F. India Ltd., and M/s. Steelsworth Pvt. Ltd., Tinsukia. M/s. S. F. India are already in the way of taking out their first commercial machine in which the trays have been eliminated and better air-flow and washing conditions have been introduced. Further improvement to the machine performance will be taken up in collaboration with the licencees and the users in the ensuing manufacturing season after installation of this commercial machine. Tocklai's prototype at Beesakopie has been brought back to Tocklai.

Moisture in Tea

A study has been made to find out the effect of bulk density and hence grade of tea, on dielectric constant at different moisture levels between 2% and 13%. Statistical analysis shows a linear relationship between the two variables at each moisture level. The goodness of fit is 99% in each case and is highly significant. The regression coefficients (B) are different at different moisture levels and take into account all grades of tea.

The regression equation of moisture percentage (M) on the said regression coefficient (B) is found to be

$M = 28.2317 \log B + 4.1721$ .....(1)

valid for values of M between 2% and 13 %. The goodness of fit in this case is 99%.

Therefore, it can now certainly be said that a meter devised to measure this coefficient can accurately be calibrated in terms of percentage moisture in tea, independent of the grade.

Hence, a meter based on the above finding was built to estimate moisture in tea. Percentage moisture of tea determined by the standard oven method was correlated to reading (X) on an arbitrary scale of this meter and the following equation was obtained:

$M = 0.627054 - 0.001763\ X^2 - 45.32.$

The goodness of fit is 82.4% which is less than 99% obtained in case of the theoretical equation (1) and hence the meter requires further development.

While the above could be useful for made tea with a lower moisture content between 2% and 13%, for the determination of moisture in tea in an intermediate stage during drying, work on calibration of a Protimeter Grain-Master type of moisture meter was taken up. Two separate sets of readings for orthodox and C.T.C. samples were taken. The number of orthodox samples was 63 and their moisture content was within the range of 8.5% and 25.4%. The number of C.T.C. samples was 74 and their moisture was within the range of 11.3% and 24.5%.

The percentage of moisture (M) of the samples determined by the standard oven method was correlated to the meter readings (X) and the following equations were obtained :

$M = 1.1360 + 0.74262\ X$ for orthodox tea,
and $M = 0.6877 + 0.7784\ X$ for C.T.C. tea.

According to the Tocklai Statistician, both the fits are highly significant and accounted for 97% of the total variations. Therefore, it appears that this kind of meter could be useful for determination of moisture in tea during drying within the ranges mentioned above.

Miscellaneous

C.T.C. Machines : A series of experiments were conducted to improve the performance of standard C.T.C. machines with a view to producing more dust grades than is normally possible with this machine. The C.T.C. segments were machined to the following specifications :

60	milled grooves	× 10	chased	grooves/inch
50	milled grooves	× 10	chased	grooves/inch
40	milled grooves	× 10	chased	grooves/inch
50	milled grooves	× 8	chased	grooves/inch (Standard)

Leaf conditioned in the 8" prototype B.L.C. was passed twice through the above machines. The average percentage of grades filtering through No. 22 mesh i.e. P.D., Dust and Churamani are tabulated below :

Table 3. Percentage of C.T.C. Grades filtering through No. 22 mesh

Segment Date Specification	6.11.71	9.11.71	11.11.71
60 × 10 T.P.I.	59.23%	52.94%	59.46%
50 × 10 T.P.I.	51.61%	42.34%	47.30%
40 × 10 T.P.I.	-	47.99%	57.51%
50 × 8 T.P.I. (Standard)	48.08	—	

From the above it can be seen that by increasing the number of circumferential grooves alone on standard segments with 50 milled grooves, the dust grades are increased by only 3%. But with increased number of milled grooves accompanied by increased number of circumferential grooves, the grade percentages can be improved considerably. It should be possible for estates to increase the primary dust grade percentages to 60 by careful manipulation of the machining of the segments. The graininess of the particles and the appearance of the teas improved considerably when the machining specification of the C.T.C. rollers were changed from 50×8 TPI to 60 × 10 TPI.

Coal Fired Heaters and Fuel Oil : Work on development of grates for coal fired heaters and also heat exchangers to allow high sulphur fuel oil to be used economicaly is now taken up in collaboration with the Central Fuel Research Institute, Dhanbad and the Regional Research Laboratory, Jorhat.

General

The Senior Research Engineer attended three meetings of the Engineering Sub-Committees in Calcutta where he also paid visits to Andrew Yule & Co., Teama Consortium and Port Engineering Works in connection with development of Tocklai machines. He attended six meetings of Area Scientific Committees of Dooars, North Bank East and West and Tingrai. He lectured in a manufacturing Course held at Deohall. He was deputed to Bombay to the Govt. of India's Petroleum Products Supply and distribution meeting held in May to plead the case of North East Indian Tea Industry for allocation of furnace oil derived from low sulphur Assam Crude—the representation was well received. He also attended the Regional Coal Survey Committee meeting at Ledo. He paid 31 advisory visits to different factories during the year. He was on long leave from 5th July to 4th August and on Medical Leave from 5th August to 12th September.

Both the Senior and the Second Research Engineers lectured in the first and second Manufacturing Courses held at Tocklai. The Second Research Engineer attended three Area Scientific Committee meetings of Golaghat and North Bank East and West. He paid 11 visits to different factories during the year.

Statistics Department

Crop-Weather Studies

A study was made to find out the most critical periods and quantity of rain which affect the annual yield of tea in the Terai, Cachar, North Bank of Assam and parts of the South Bank of Assam consisting of Nowgong, Golaghat and Jorhat Sub-Areas. This was based on the monthly yield and rainfall data which were collected through mailed questionnaires from the estate managers at the end of every four months.

The rainfall periods which were considered in this study are shown in Table 1.

Table 1 : Rainfall periods

Rainfall periods	Notation and Unit used in the Eauations
October (previous season)	R_1 in cm
November to December (previous season)	R_2 ,, ,,
January to March (current season)	R_3 ,, ,,
April (,, ,,)	R_4 ,, ,,
May (,, ,,)	R_5 ,, ,,
June (,, ,,)	R_6 ,, ,,
July to September (,, ,,)	R_7 ,, ,,

It would be reasonable to assume that the rainfall during all these seven periods affected the yield jointly or individually depending on their mutual correlations. Therefore, in this investigation rainfall during these seven periods was considered together. Separate analyses were done for each region and the computations of the large mass of data were carried out on an IBM-7044 electronic computer at the Indian Institute of Technology, Kanpur.

Terai

The results thus obtained from the Terai were based on the monthly crop and rainfall data for the period 1958-1968. The most critical periods of rain which affected the annual yield of tea in this region were November—December, January-March, April and July-September. Rainfall during these four periods together contributed about 89 per cent towards annual yield. This result suggests that when all other factors are constant, the rainfall during these four periods are mainly controlling the annual yield in the Terai. Furthermore, the annual yield increased with the increase in rainfall during November—December upto the observed maximum rainfall of 9 cm. The nature of relationship suggested that rate of increase in yield was higher at the lower levels of November-December rainfall than at the higher levels. However, there was a considerable increase in crop upto 9 cm of November-December rainfall. Similarly, yield was found to increase with the increase in rainfall during January-March and also during April upto the maximum of 12 cm and 16 cm respectively, observed during each of these periods. The rate of increase in yield was constant throughout the observed range of rainfall during these two periods.

Thus, within the observed range of rainfall during each of the three cold weather periods, the yield was found to increase with rainfall. The data showed that in almost all the years, rainfall during each of the three cold weather periods, viz., November—December, January—March, and April, was much less than the maximum observed, i.e., 9 cm, 12 cm and 16 cm respectively. These were obvious as the average rainfall during November-December, January-March, and April were only 2 cm, 6 cm and 7 cm respectively.

Though the optimum rainfall requirement in each period could not be determined from the set of data under investigation, it is clear from these results that on an average there is always a deficiency of rainfall in each period by at least 7 cm during November-December, 6 cm during January-March and 9 cm during April. Whereas, the rainfall during July-September showed beneficial effect on the annual yield upto about 192 cm, but beyond that limit yield declined. It was also found that in the majority of years, rainfall during this period

was higher than the optimum requirement of 192 cm. This was obvious as the average rainfall during this period was 206 cm. It is, therefore, clear that in order to check the detrimental effect of the excess rainfall during July-September, it is essential to drain out the excess monsoon water. (cf. Journal of Applied Meteorology, 1966, Vol. 5, No. 6, pp. 789-800).

Hence, from the types of relationship and rainfall distribution discussed above, it is clear that if irrigation is adopted to compensate the deficiencies during November-December, January-March, and April, and adequate measure is taken to drain out the excess water during monsoon, considerable gain in yield can be expected, for which the following equation has been obtained from the set of data under reference.

$$Y = 347.7193 \ \mathrm{Log}_{10}(R_2 + 1) + 15.8552R_3 + 25.7537R_4 + 32.9155R_7 - 0.0855R^2_7 - 2187.8601 \quad \ldots\ldots(1)$$

where, Y = annual yield of made tea in kg/ha, and other notations and unit are explained in Table 1.

By using Equation No.1, the corresponding gain was estimated at 667 kilograms of made tea per hectare which was equivalent to about 50 per cent gain in annual yield over the actual average.

From the economics point of view also, this study has shown that irrigation during November to April would be a paying proposition in the Terai.

North Bank, Assam

The results obtained from the North Bank of Assam were based on the monthly crop and rainfall data for the period 1958-1970. The critical periods of rain which affected the annual yield of teas in this region were October, November-December, January-March, April, May, June, and July-September. Rainfall during these seven periods together contributed about 99 per cent towards annual yield. This suggests that in the North Bank of Assam, each of the seven periods of rain contributes significantly towards the annual yield. Further, the nature of relationship between different periods of cold weather rain and the annual yield showed that annual yield increased with the increase in rainfall during October and also during November-December upto the observed maximum of 19 cm and 6 cm respectively. In both the periods, rates of increase in yield were constant throughout the observed range of rainfall, but the rate of increase due to November-December rainfall was double than that of the October rainfall. Rainfall during January-March, and April showed beneficial effect on yield upto 14 cm and 26 cm respectively, but beyond these limits yield declined. Thus, in all the four cold weather periods, rainfall showed beneficial effect on yield except that excess rainfall during January-March and April showed detrimental effect.

The rainfall data showed that in most of the years, rainfall during October was much less than the observed maximum of 19 cm. This was obvious as the average rainfall during this period was only 10 cm against the observed maximum of 19 cm, upto which the yield was found to increase. This suggests that, on an average, there is a deficiency of rainfall during October by at least 9 cm and if this deficiency is compensated by irrigation, there would be a gain in yield, but the gain in yield per unit of rainfall during this period is such that it is unlikely to pay for the cost of irrigation at average costs of irrigation.

In the same way it was found that on an average there were deficiencies of rainfall during November-December, January-March, and April by at least 3 cm, 3 cm and 8 cm respectively. If irrigation is adopted to compensate the deficiencies during these periods, it would, however, pay because the rates of return per unit of rainfall during these three periods were much higher than that in October. On the other hand, monsoon rains during May, and July-September showed beneficial effect on annual yield, but the rate of increase in yield gradually declined as the rainfall increased in both the periods, and at the observed maximum rainfall of 61 cm and 139 cm respectively, the increase was practically nil. Rainfall during June showed a

detrimental effect on the yield. These suggest that in order to check the detrimental effect of the excess rainfall during monsoon period, it is essential to drain out the excess water.

Therefore, the types of relationship and rainfall distribution in the North Bank suggest that if irrigation is adopted to compensate the deficiencies during November-December, January-March, and April, and adequate measure is taken to drain out the excess water during the monsoon period, gain in yield can be expected, for which the following equation has been obtained from the set of data under reference.

$$Y = 6.4738R_1 + 13.3801R_2 + 83.4724R_3 - 3.0819R^2_4 + 25.7493R_4 - 0.4990R^2_3 + 215.0111 \text{Log}_{10}R_5 - 0.0250R^2_6 + 250.6890 \text{Log}_{10}R_7 - 184.9011 \quad \ldots\ldots(2)$$

where, Y = annual yield of made tea in kg/ha, and other notations and unit are explained in Table 1.

By using Equation No. 2, the average gain in yield from irrigation during November-December, January-March, and April was estimated at 235 kilograms of made tea per hectare which was equivalent to about 17 per cent over the actual average. The gain was, however, much less than that in the Terai. Even then, irrigation from November to April would pay in the North Bank of Assam but the profit would be small.

The critical periods of irrigation, the minimum quantity of irrigation requirement in each period and the estimated gain in annual yield due to irrigation for the Terai and the North Bank of Assam, are summarised in Table 2.

Table 2. Critical periods of irrigation, quantity of irrigation requirement and the estimated gain in annual yield due to irrigation for the Terai and the North Bank

Region	Minimum irrigation requirement (cm) during			Total (cm)	Estimated per cent gain in annual yield due to irrigation	Remarks
	November to December	January to March	April			
Terai	7	6	9	22	53	Profitable
North Bank	3	3	8	14	17	Profitable

It is stressed that (i) in order to derive the maximum benefit from irrigation, period of irrigation, quantity of irrigation in each period (as shown in Table 2), and draining out the excess water during the monsoon rains are the most important factors to be kept in mind; (ii) while the results presented here represent the average picture of the region as a whole, there are variations from estate to estate within the regions with respect to such factors as distribution of rainfall, soil type and depth of soil. Before taking any large scale irrigation programme in the Terai and in the North Bank, Assam, each individual estate should, therefore, examine very carefully the distribution of rainfall in the past and characteristics of the soil; and (iii) irrigation should first be tried on an experimental basis before large scale programme is adopted.

Cachar and parts of the South Bank, Assam

Results from the Cachar as a whole, and some parts of the South Bank consisting of Nowgong, Golaghat and Jorhat Sub-Areas taken together,

suggest that irrigation during cold weather would increase yield by about 8 and 12 per cent respectively but it is unlikely to be profitable. However, if the different parts of the Cachar and the three Sub-Areas of the South Bank, Assam, are studied seperately, it is likely that in some parts irrigation might still pay. This aspect is now under study.

Long-term Survey-Experiments on Defoliation

During 1970/71 cold weather, the two main plot treatments, Prune-Deep Skiff and Prune-Deep Skiff-Medium Skiff, were light pruned and deep skiffed, respectively. The data collected during the year from the experiments in the Dooars were analysed.

The red spider infestation was practically nil in all the experimental plots including the control (no defoliation and no chemical spraying) plots. Since red spider infestation was practically nil, no spraying was necessary in the chemical palliative plots. However, the yield of defoliated plots was found to be significantly lower than the undefoliated plots with or without chemical prophylactic spraying with tetraduphon (Tedion). The loss was found to be more than that of last year (17 p.c. as against 13 p.c. last year) over the undefoliated chemical prophylactic sprayed plots. As in previous years (Ann. Rep., 1968-69, pp. 102-106; 1969-70, p. 80 and 1970-71, p. 82), this loss may be attributed to the detrimental effect of the continuous defoliation. The loss in yield due to continuous defoliation was gradually increasing with the years. This suggests that continuous defoliation has got cumulative detrimental effect on the yielding capacity of the tea bushes. No significant difference in yield between the chemical prophylactic sprayed plots and the control (no defoliation and no chemical spraying) plots was observed. This was understandable because the red spider infestation was practically nil.

The experiment will be continued to study the objectives outlined in the earlier report (Ann. Rep., 1968-69, pp. 102-106).

Help to Other Departments

The Department continued to extend the co-operation and help in solving a large number of statistical problems encountered by research workers of practically all the Departments of the Station. Analyses of a number of long-term experiments on the electronic computer at the Indian Institute of Technology, Kanpur continued throughout the year. For the purpose of these analyses, a number of *FORTRAN IV* programmes had to be written.

Statistical Study of the Chemistry of Tea

The influence of biochemical constituents and their effects on colour, brightness and strength were investigated during the year. The computations of the large mass of data were carried out on an IBM-7044 electronic computer at the Indian Institute of Technology, Kanpur. The tentative findings obtained from the preliminary analyses were reported in the Annual Report for 1970-71, p. 81. Final results obtained from the detailed analyses are summarised below.

Amongst the significant biochemical constituents for individual tasters which together contributed, in general, 71 per cent to 87 per cent towards colour, brightness and strength of C.T.C. teas, seven constituents for colour, six constituents for brightness, and nine constituents for strength were found to be common to more than two tasters and also two tasters showing similar effect of the constituents. Lists of these significant common constituents affecting, colour, brightness and strength are shown in Table 3.

It was also found that, in general, for the majority of tasters, the joint contributions of these significant common constituents towards colour, brightness and strength of C.T.C. teas were about 55 per cent.

These results, therefore, suggest that colour, brightness and strength of C.T.C. manufactured teas are mainly influenced by the biochemical constituents listed in Table 3.

Table 3. Significant biochemical constituents common to two or more tasters affecting colour, brightness and strength of C.T.C. teas.

Source	Colour	Brightness	Strength
Unprocessed tea shoots	1. Total oxygen uptake 2. EGC	1. TG	1. Total oxygen uptake 2. ECG 3. TG
Made tea	3. TF 4. TR 5. EGCG 6. Protein nitrogen 7. TG	2. TF 3. TR 4. Water-soluble solids † 5. Crude fibre 6. ECG	4. TF 5. Moisture 6. Ash 7. Crude fibre 8. Caffeine nitrogen 9. Amino acid nitrogen

† Excluding Ash, TF, TR, EGC, EGCG, ECG, TG, caffeine nitrogen and amino acid nitrogen of made tea.

Similarly, for orthodox manufactured teas, the biochemical constituents, which were significant for individual tasters, together contributed, in general, 74 to 89 per cent towards colour, brightness and strength. Amongst these significant constituents, nine were found to be common for colour to more than two tasters and also two tasters showing more or less similar effect of the constituents. Similarly, eight constituents were common for brightness and seven for strength. Lists of these significant common constiutents affecting colour, brightness and strength are shown in Table 4.

Table 4. Significant biochemical constituents common to two or more tasters affecting colour, brightness and strength of orthodox teas

Source	Colour	Brightness	Strength
Unprocessed tea shoots	1. Total oxygen uptake 2. EGCG	1. Total oxygen uptake 2. EGCG 3. ECG	1. Total oxygen uptake 2. EGC 3. ECG
Made tea	3. TF 4. TR 5. EGCG 6. ECG 7. TG 8. Amino acid nitrogen 9. Caffeine nitrogen	4. TF 5. TR 6. ECG 7. Amino acid nitrogen 8. Caffeine nitrogen	4. TF 5. TR 6. Moisture 7. ECG

It was also found that, in general, for the majority of tasters, the joint contributions of these significant common constituents towards colour, brightness and strength were about 55 per cent. Therefore, it can be said that the significant common biochemical constituents listed in Table 4 are the major contributing constituents of colour, brightness and strength of orthodox manufactured teas.

By comparing the results of C.T.C. and orthodox manufactured teas (Tables 3 & 4) it was noticed that amongst the significant common biochemical constituents influencing colour, brightness and strength 5, 3 and 4 constituents respectively were found to be common to both C.T.C. and orthodox teas. Furthermore, in majority of the cases, these common constituents jointly contributed about 50 per cent towards colour, brightness and strength, both of C.T.C. and orthodox teas. Lists of these common biochemical constituents are shown in Table 5.

Table 5. Significant biochemical constituents common to both methods of manufacture affecting colour, brightness and strength

Source	Colour	Brightness	Strength
Unprocessed tea shoots	1. Total oxygen uptake		1. Total oxygen uptake 2. ECG
Made tea	2. TF 3. TR 4. EGCG 5. TG	1. TF 2. TR 3. ECG	3. TF 4. Moisture

These results, therefore, suggest that regardles of tasters and methods of manufacture, total oxygen uptake of unprocessed tea shoots, and TF, TR, EGCG and TG of made tea are the main guiding constituents of colour of North East Indian plains tea. Similarly, for brightness, TF, TR and ECG of made tea, and for strength, total oxygen uptake and ECG of unprocessed tea shoots, and TF and moisture of made tea are the main controlling biochemical constituents of North East Indian plains tea.

For different tasters, the types of relationship between the significant biochemical constituents and the tasters' marks on each of colour, brightness and strength, both of C.T.C. and orthodox teas, were found to vary from taster to taster. These variations, however, might be attributed to the taster to taster variations in their degree of preference, and likes and dislikes of a particular chemical constituent. However, the effects of the most important biochemical constituents on colour, brightness and strength were found to be more or less the same for all the tasters.

Further, it was noticed that some of the significant biochemical constituents which together had generally minor contributions towards colour, brightness and strength of C.T.C. and orthodox teas, and also the number of significant constituents were found to vary from taster to taster. These variations amongst tasters might be attributed to the variation in their preferences and also in their policy of assessing the made teas according to the consumer's choice. However, for the major part of the variations in each of colour, brightness and strength, both of C.T.C. and orthodox teas, the tasters, on the whole, were in agreement.

It was also found that some of the significant biochemical constituents which together had generally minor contributions towards colour, brightness and strength, and also the number of significant constituents varied between the C. T. C. and orthodox methods of manufacture. These differences are understandable because of the differences between the two manufacturing methods. But, major part of the variations in each of colour, brightness and

strength was contributed by the significant constituents which were found to be common between the two methods of manufacture.

From all the results discussed here, it can be concluded that regardless of tasters and methods of manufacture, the biochemical constituents listed in Table 5 are the main controlling constituents of colour, brightness and strength of North East Indian plains tea. But, for more precise guidance, for C.T.C. and orthodox manufactured teas the biochemical constituents listed in Tables 3 and 4 respectively should be considered.

Thus, this study leads to a step forward in obtaining a quantitative basis for the assessment of colour, brightness and strength of North East Indian plains black teas. These findings are expected to be of help to those who are engaged in the clonal selection, plant breeding and manufacturing machinery development.

Survey on Field Management and Environmental Factors Affecting the Yield of Tea in the Dooars and Terai, West Bengal

A survey on field management and environmental factors affecting the yield of tea was conducted by the West Bengal Advisory Department in all the Member estates in the Dooars and Terai during 1967-69. The object of this survey was to find out the field management and environmental factors from the estates' records which affect the yield of tea and to estimate the increase or decrease in yield due to these factors and their individual contributions towards yield. The analysis is in progress. Some of the tentative results obtained from the preliminary analysis are given below.

(i) When the teas were grown under good drainage status, it gave about 18 per cent more yield than the teas grown under poor drainage condition.

(ii) Response in yield due to nitrogen was much greater under the good drainage condition than under the poor drainage. Further, when the bushes were grown under good drainage condition, response due to nitrogen was maintained upto the observed maximum level, i.e., 150-180 kg/ha, whereas under the poor drainage condition yield declined beyond 120-150 kg/ha. These showed that when the bushes were grown under good drainage condition, they were in a better position to utilise the fertiliser more efficiently. These results, therefore, suggest that in order to derive the maximum benefit from any fertiliser, drainage condition must be improved. Fertiliser alone cannot substitute the detrimental effect of the poor drainage.

(iii) Response in yield due to nitrogen and the level at which the response declined varied with the age of tea.

(iv) Response in yield due to nitrogen was higher under good shade than poor shade which in turn was higher than no shade upto the observed range of 120-150 kg of nitrogen per hectare. The reason for this should be investigated.

(v) Light leaf tea showed sharp decline in yield over the age 20 to 30 years. Whereas, dark leaf type of tea showed an increasing trend till 20 to 25 years age and then showed a sharp decline in yield over the next five years period. From 30 to 50 years age, both types of tea showed slight decline in yield and thereafter the decline was steeper but it was more so in light leaf type of tea. These suggested that fall in yield due to age took place five years later in dark leaf tea and the yield was more from 15 years onwards and also the drop in yield after 50 years was less. These differences might be attributed to the inherent hardiness of the dark leaf type of tea.

Touring and Advisory

The Statistician attended the Workshop on Sensory Evaluation of Foods at the Central Food Technological Research Institute, Mysore. He paid one visit to the Indian Institute of Technology, Kanpur and two members visited twice in connection with the statistical analyses of data from longterm and complex experiments on the IBM-7044 electronic computer.

Library and Publication Department

LIBRARY

General

The Library added six more scientific journals to the subscription list and discontinued six other journals. Arrangements were made to get three journals on exchange of our own publications which were previously received on payment. Seven more new periodicals are added to the free list during the year. The subscription to foreign scientific journals has increased this year affecting budget alterations.

Reorganisation

Ten new Steel racks were purchased to accommodate the increased book stock in the library which is being reorganised. Ten shelf index boards were also made and these will be fixed in due course in proper place.

Four wooden carrells to accommodate four persons in each carrell were added to the Library Reading Room.

A part of the Journal Section

Library cards have been purchased for cataloguing of books and documentation works, but for want of library typist the work could not be done during the year under report.

Book Binding

A total of 1214 volumes of journals were bound during the year. Many old and worn-out journal volumes were rebound. Rebinding of text books will be taken up in the next financial year.

Loan Service

Twentyone Postgraduate scholars and the Tea Science students of Assam Agricultural University attended the library regularly during the year. The Scientists of the Regional Research Laboratory, Jorhat, utilised the Journal Section of the Library as in the previous years. Trainees from Mauritius, Sikkim and Tea Board attended the library during the year. The Tocklai Scientific staff used the library as usual.

New carrells accommodate more readers in the Reading Room

Book Preservation

The preservation of books and documents in a humid tropical region like Assam continues to be a problem. In winter, the books become moist and damp and micro-fungi grow rapidly unless the books are cleaned every day and dried under the sun every week. Insects like book-lice and silver fish take shelter inside the books.

Experiments were made to control the insects which were (a) Starch feeders (b) Cellulose feeders and (c) Protein feeders found in the library books. Residual treatments like dusting, spraying, varnishing were tried. A solution of 60 g shellac, 570 c.c. spirit and 1 c.c. creosote was prepared and applied as varnish inside the covers and backs of the books. This solution was found to be effective and its use will continue.

Rodenticides were not found to be fully effective against rats. Hence the top portion of the bound volumes were varnished with a solution of B.H.C., Naphthalene and creosote with good results.

Library Statistics

Books added during the year	-	84
Periodicals and Journals	—	1574
Pamphlets	—	1161
Photocopies	—	22
Reprints	—	6
Publications consulted in Library		1250
Publications issued to Departments	—	343

PUBLICATIONS

As in the previous years the activities of the Publication Section grew considerably due to publication of several Advisory leaflets, Advisory Bulletins, Conference Proceedings over and above the normal publications.

Many Tea Encyclopaedia sets were received from the Member estates for uptaking.

The Two & A Bud—Tocklai Newsletter was published half-yearly in June and December from 1971.

The following publications were issued during the year.

(1) **Two & A Bud**

Vol. 18, Nos. 1 and 2.

(2) **Tea Encyclopaedia Serials (Revised)**

No. 80/2 Chemical Weed Control
No. 74/5 List of available publications.
No. 75/8 Index of Encyclopaedia of Tea Serials issued to May 1971.
No. 123/3 General Index of Tea Encyclopaedia.
No. 102/1 Miniature Manufacture and Manufacture of leaf from long term trial for Compatibility Test.
No. 115/2 Manuring of Tea seed and V. P. nurseries.

Tea Encyclopaedia Serials (New)

No. 184 Calculation of percentage wither and the Corresponding Moisture Content of Green and Withered Leaf.
No. 192 Low Tipping Method of Bringing up Young Tea.
No. 189 Uprooting & Replanting.
No. 193 Heavy pruning in Darjeeling.

(3) **Advisory leaflets**

No. 3 Excessive Banjhiness of Tea in Darjeeling with relation to Pruning and Management Practices.
No. 4 Black Rot.
No. 5 Estate trials on Foliar application of Zinc.

(4) **Advisory Bulletins**

No. 1 Planting Calendar for Assam.
No. 2 Planting Calendar for Cachar.
No. 3 Nursery and field management of Clones.

(5) **Miscellaneous Reports**

T. R. A. Annual Scientific Report for 1970-71.

Memorandun No. 28 Catchment Planning and Contour Planting for Safe water Disposal, water and soil Conservation in the Plains Areas of North-East India.

Recommendations for control of Pests and Diseases of Tea and shade Trees—Revised July, 1971.

Recommendations for control of pests and diseases of Tea & Shade Trees with Power Sprayers —Revised March, 1972.

Papers Read in the Staff-Get-Together—1970 (Circulation restricted).

Engineering Development Department Report for the Quarter ending 30th June 1971 (Circulation restricted).

Engineering Development Department Report for the Quarter ending 30th September 1971 (Circulation restricted).

Engineering Development Department Report for the Quarter ending 31st December 1971 (Circulation restricted).

Engineering Development Department Report for the Quarter ending 31st March 1972 (Circulation restricted).

Proceedings of a meeting of the Agricultural Sub-Committee held at Tocklai on 14th September 1971 (Circulation restricted).

Appendix - A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY THE ADVISORY DEPARTMENT

South Bank, Assam

Project	Site	Index	Year of starting
NPK Manuring	Murmuria	AS 11	1956
	Sycotta	AS 34	1960
	Katonibari	AS 44	1963
	Hunwal	AS 51	1964
	Dirok	AS 63	1965
	Ghillidary	AS 88	1968
	Hunwal	AS 92	1969
	Haroocharai	AS 98	1970
NPK Manuring with Gramoxone	Doom Dooma Tea Co.	AS 95A	1969
	,, ,, ,,	AS 95B	1969
Nitrogenous fertilizer	Sycotta	AS 56	1964
	Sagmootea	AS 62	1965
	Joonktolee	AS 64	1966
	Nahorhabi	AS 65	1966
	Furkating	AS 69	1966
	Halmirah	AS 71	1966
	Joonktolee	AS 82	1967
	Haroocharai	AS 99	1970
Nitrogenous fertilizer vs. liming	Cinnamara	AS 77	1966
	Meleng	AS 78	1966
Pruning	Dufflating	AS 84	1957
	Nahorhabi	AS 90	1968
	Margherita	AS 97	1969
Irrigation	Borahi	AS 67	1966
	Gorunga	AS 68	1966
	Gabroo Purbut	AS 70	1966
	Dejoo Valley	AS 73	1966
Jat and Clonal Trial	Tyroon	AS 89	1968
	Tyroon	AS 96	1969

NORTH BANK

Project	Site	Index	Year of starting
Rehabilitation of land	Tarajuli	AN 46	1964
	Deckiajuli	AN 47	1964
NPK Manuring	Ananda	AN 93	1969
Nitrogenous fertilizer	Nahorhabi	AN 59	1964
	Hatigar	AN 91	1969
	Ananda	AN 94	1969
Nitrogenous fertilizer vs Liming	Gingia	AN 80	1966
Pruning	Phulbari	AN 58	1964
	Kolony	AN 76	1966
Irrigation	Sessa	AN 61	1965
	Mazbat	AN 75	1966
Cultivation and Weed Control	Halem	AN 31	1960

CACHAR, ASSAM

Project	Site	Index	Year of starting
Rehabilitation of land	Koomber	C 25	1964
NPK Manuring	Isa Bheel	C 26	1966
	Hattikhira	C 27	1966
	Longai	C 28	1966
Nitrogenous fertilizer	Pallorbund	C 29	1966
	Dewan	C 30	1966
Pruning	Pallorbund	C 33	1967
	Derby	C 35	1968
Shade and Manuring	Koomber	C 36	1968
Soil Climatological Survey	Coombergram	C 20	1962

DOOARS AND TERAI, WEST BENGAL

Project	Site	Index	Year of starting
Rehabilitation of land	Bhogotpore	D 27	1964
	Grassmore	D 28	1964
Nitrogenous fertilizer	Baradighi	D 33	1966
Pruning	Chuapara	D 2	1955
	Baradighi	D 4	1959
	Sam Sing	D 34	1966
Irrigation	Gopalpur	D 35	1966
	Ranicherra	D 36	1968
	Tirrihannah	TR 1	1968
Cultivation and Weed Control	Chuapara	D 42	1970
Soil Climatological Survey	Nya Sylee	D 24	1962
Shade	Nya Sylee	D 9	1958
Infilling	Kartick	—	1969
	Jainti	—	1969
	Fagu	—	1969
	Hilla	—	1969
	Dem Dima	—	1969
	Sahabad	—	1969
	Mohurgong	—	1969
	Gulma	—	1969

DARJEELING, WEST BENGAL

Project	Site	Index	Year of starting
NPK Manuring	Tumsong	Dj 22	1965
	Sungma	Dj 23	1965
Nitrogenous fertilizer	Lingia	Dj 29	1967
	Singell	Dj 26	----
	Merrybong	Dj 28	-
Pruning	Lingia	Dj 21	1963
	Phoobsering	Dj 24	1965
	Goomtee	Dj 25	1966
	Marghret's Hope	Dj 27	1966
Plucking	Mim	Dj 18	1961
Soil Climatological Survey	Nagri Farm	Dj 19	1961

Appendix - B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
BY
THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

Sl. No.	Experiment	Location of Estate	Site (T. E.)	Index No.	Year starting
1.	Trial of biclonal seed stock	South Bank Assam	Hapjan	As 200	1963
2.	,,	,,	Tengpani	As 201	1963
3.	,,	,,	Tengpani		1965
4.	,,	,,	Kakajan	As 206	1966
5.	,,	North Bank Assam	Nahorani	AN 202	1963
6.	,,	,,	Sonabheel	AN 203	1964
7.	,,	,,	Durrung	AN 204	1965
8.	,,	,,	Bhooteachang	AN 205	1965
9.	,,	Cachar, Assam	Jellalpore	C 200	1963
10.	,,	,,	Dewan Group of Estates	C 201	1966
11.	,,	Dooars, West Bengal	Sathkyah	D 200	1962
12.	,,	,,	Bhatkawa	D 201	1962
13.	,,	,,	Bhatkawa	D 206	1965
14.	,,	,,	Hantapara	D 202	1964
15.	,,	,,	Meenglas	D 203	1964
16.	,,	,,	Hasimara	D 204	1964
17.	,,	,,	Rydak	D 205	1965
18.	,,	Terai, West Bengal	Hansqua	TR 200	1968
19.	,,	Darjeeling, West Bengal	Mim	DJ 200	1961
20.	,,	,,	Ging	DJ 201	1965
21.	Effect of shade and nutrients	South Bank, Assam	Murmuria	AS 207	1965
22.	Observation plots of biclonal progenies	South Bank, Assam	Bazaloni		1962
23.	,,	,,	Abhoyjan		1969
24.	,,	,,	Duklingia		1963
25.	,,	North Bank, Assam	Nonaipara		1966
26.	,,	,,	Budlapara		1967
27.	,,	Cachar, Assam	Chandighat		1969
28.	,,	Terai, West Bengal	New Chumta		1963
29.	,,	Dooars, West Bengal	Meenglas		1968
30.	,,	Darjeeling, West Bengal	Chongtong		1969
31.	,,	Sikkim	Kewzing		1969
32.	Plucking experiment	South Bank, Assam	Duklingia	AS 208	1971

ENTOMOLOGY DEPARTMENT

Sl. No.	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Abundance of pink and purple mite on young and mature tea.	South Bank, Assam	Sycotta	N 7	1971
	Palliative mite trial (Red-spider)	,,		—	
	Red rust trial			—	
2.	Distribution of pink and purple mite under-shaded condition	,,	Socklatinga	N 7	1971
	Palliative mite trial (Red-spider)			—	
3.	Abundance of pink and purple mite on pruned and and skiffed tea.	,, ,,	Bokahola and Nagadhoolie	N 7	1971 1972
	Black rot trial	,,	,,	—	1971
4.	Distribution of red spider, scarlet, pink and purple mite on clones and jats.	,,	Deha	N 7	1971
	Prophylactic mite trial (Red spider)	,,	,,	—	1972
5.	Incidence of scarlet, pink and purple mite on clones and jats	Cachar, Assam	Longai	N 7	1971
6.	Abundance of scarlet, pink and purple mite on pruned, light skiffed and deep skiffed tea	,,	Longai	N 7	1971
7.	Susceptibility of pruned and deep skiffed tea to scarlet, pink and purple mite	,,	Hattikhira	N 7	1971

Sl No.	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
8.	Pink and purple mite on pruned and skiffed tea	Dooars, West Bengal	Ranicherra	N 7	1971
9.	Distribution of pink and purple mite under shaded condition	,,	,,	N 7	1971
10.	Relative susceptibility of clones and jats to pink and purple mite	,,	,,	N 7	1971
11.	Distribution of pink and purple mite under shaded condition	Darjeeling, West Bengal	Nagri	N 7	1971
12.	Pink and purple mite on pruned and skiffed tea	,,	Nagri and Tukdah	N 7	1971
13.	Palliative mite trial (Red spider)	South Bank, Assam	Dooria	—	1971
14.	Red spider screening trial-I	,,	Dessoic	—	1971
15.	Red spider screening trial-II	,,	Hulwating	—	1971
16.	Red spider screening trial-III	,,	Katanibari	—	1971
17.	Jassid trial	,,	Kakajan	—	1971
18.	Scale insect trial	Darjeeling	Happy Valley	—	1971
19.	Blister blight trial	,,	Vah Tukvar	—	1971
20.	Helopeltis trial	Cachar	Silcoorie	—	1971
21.	Cockchafer trial	Dooars	Chalouni	—	1971
22.	Termite trial	North Bank, Assam	Sonajuli	—	1972

MYCOLOGY DEPARTMENT

Sl No.	Experiment	Location of Estate	Site (T. E.)	Index No.	Year starting
1.	Screening of chemicals against Red rust	South Bank, Assam	Sycotta	MR 007	1971
2.	Copper spraying at lower dilutions against Red rust	,,	,,	MR 008	1971
3.	Red rust in relation to soil rehabilitation (Collaboration: Advisory branch)	,,	Ghillidary	AS 49	1964
		,,	Hansara	AS 50	1964
		,,	Duklingia	AS 48	1964
4.	NPK manuring and its effect on incidence of Thorny stem blight (collaboration : Darjeeling Advisory branch)	Darjeeling, West Bengal	Sungma	MC 002	1966
5.	Application of a systemic fungicide against Thornystem blight	,,	Balasun	MC 003	1970
6.	Efficiency of spraying against Black rot	North Bank	Ghoirallie	MB 002	1968
7.	Effect of extended rounds of spraying against Black rot	North Bank	Addabarie	MB 007	1971
		South Bank	Kakajan	MB 008	1971
8.	Control trial against purple root rot	North Bank	Baghmari	MP 001	1965

STATISTICS DEPARTMENT

Sl. No.	Department	Project	Site (T. E.)	Index No.	Year started
1	2	3	4	5	6
1.	Statistics	Uniformity trial	Bokahola (South Bank, Assam)	—	1963
2.	,,	Uniformity trial	Nagri Farm (Darjeeling, West Bengal)	—	1964
3.	,,	Long-term defoliation experiment	Nya Sylee (Dooars, W.B	—	1963
			Bhogotpore (,, ,,	—	1963
			Jiti (,, ,,)	—	1963
			Hope (,, ,,)	—	1963
			Kurti (,, ,,)	—	1963

ENGINEERING RESEARCH & DEVELOPMENT DEPARTMENT

Sl No.	Experiment	Index No.	Location of estate	Site Tea Estate
1.	Continuous Fermenting Machine	E. 3	South Bank,Assam	Beesakopie T. E.
2.	48" Disc Roller	E. 2	South Bank,Assam	Heelcakah T.E.
3.	Leaf Sizer Attachment	E. 2	South Bank,Assam	Kakajan T. E.
4.	Manual Plucking Aid	E. 8	South Bank,Assam	Borbhetta

Appendix - C

Published papers and papers in the Press

1. Banerjee, B. 1971. Theoretical models on the predator-prey relationship in Arthropods. *Proc. Zool. Soc.*, 24 : 9- 12.

(Abs. The predator-prey relationship in Arthropoda is dependent, amongst others, on the predation efficiency and escape mechanism of the prey. Because of operation of these two opposite forces, natural populations do not completely disappear even under the pressure of continuous predation. A mathematical model incorporating these components is suggested. Laboratory experiments on two species of mites, one predator (*Tyrophagus* sp.) and another, a prey (*Phytoptipalpus* sp.), illustrate that by using this model the functional response curve can be obtained. The relationships of the model to other mathematical models are discussed.)

2. Banerjee, B. 1971. Eclosion and oviposition rhythms of *Andraca bipunctata* Walker (Bombycidae : Lepidoptera) with a model for determining theoretical moth densities from eclosion rate. *Indian J. Ent.*, 33 : 1-8.

(Abs. Eclosion and oviposition of the moth *Andraca bipunctata* follow specific rhythmic patterns with fixed time for activity during a 24 hour cycle. Moths emerge throughout the night, but with high frequency at both dawn and dusk. Oviposition is at maximum between 20.47 hr to 22.47 solar time. A common feature in both the behaviour patterns is their complete absense during the day-light hours. Eclosion and oviposition follow daily rhythmic patterns irrespective of fluctuations in light and climatic factors in different seasons. It is suggested that these rhythms are responses to an endo-genous biological clock. The model for determining theoretical moth densities appropriately predicts the moth density for any sampling day, provided eclosion is continuous.)

3. Bezbaruah, H. P. 1971. Cytological investigations in the family Theaceae- I. Chromosome numbers in some *Camellia* species and Allied Genera. *Caryologia*. Vol. 24, N. 4 : 421-426.

(Abs. Cytological investigations on eight *Camellia* species and three related genera belonging to the family Theaceae have been made. Chromosome numbers are listed for three species of *Camellia* and three species of related genera (*Schima*, *Pyrenaria* and *Gordonia*) of which chromosome numbers have not previously been reported. A new basic chromosome number $x = 18$ is recorded in *Schima wallichi* Chois for the first time.)

4. Biswas, Ajit K. & Biswas, Asim K. 1971. Biological and Chemical Factors Affecting the Valuations of North-East Indian Plains Teas I.—Statistical association of liquor characteristics with cash valuations of black teas, *Journal of the Science of Food and Agriculture*, Vol. 22, No. 4, pp. 191-195.

(Abs. An attempt has been made, by using the multiple regression technique, to determine whether the term 'quality' of the North-East Indian plains black teas has its own single characteristic as recognisable by tea-tasters or if it is the integration of some of the other important liquor characteristics, viz., colour, strength, brightness, and briskness, and to determine the influence of those liquor characteristics quality on the 'cash valuations' of black teas.

The study showed that regardless of methods of manufacture, the liquor character quality of North-East Indian plains black teas was found to depend mainly on briskness and, to a minor extent, on other liquor characteristic(s) which varied from taster to taster; quality being increased with an increase in briskness.

Cash valuations both of C.T.C. and orthodox manufactured teas of North-East Indian plains, depended mainly on quality and/or briskness

and, to a minor extent, on other liquor characteristic (s) which varied from taster to taster; cash valuation being increased with increase in quality and/or briskness.)

5. Biswas, Ajit K, Biswas, Asim K. & Sarkar, A.R. 1971 Biological and Chemical Factors Affecting the Valuations of North-East Indian Plains Teas II.—Statistical evaluation of the biochemical constituents and their effects on briskness, quality and cash valuations of black teas, *Journal of the Science of Food and Agriculture*, Vol. 22, No. 4, pp. 196-204.

(Abs. An attempt has been made to determine, by using the multiple regression technique, the most important biochemical constituents affecting 'briskness', 'quality' and 'cash valuation' and also their effects on these liquor characteristics and on the cash valuation of North-East Indian plains black teas.

The multiple regression analyses showed that regardless of tasters, for crushing, tearing and curling (C.T.C.) manufactured teas, five biochemical constituents—total oxygen uptake and theogallin (TG) of unprocessed tea shoots, and theoflavin (TF), epicatechin gallate (EGG) and TG of black tea—together accounted for the major part of the total variations in each of briskness, quality and cash valuation. For orthodox manufactured teas, seven constituents- enzyme activity, total oxygen uptake and ECG of unprocessed tea shoots, and TF, ECG, TG and water-soluble solids (other than ash, TF, thearubigin, epigallocatechin, epigallocatechin gallate (EGCG), ECG, TG, caffeine nitrogen and amino acid nitrogen) of black tea -together accounted for the major part of the total variations in briskness, quality and cash valuation.

Further, regardless of tasters and methods of manufacture,four biochemical constituents- total oxygen uptake of unprocessed tea shoots, and TF, ECG and TG of black tea- were the main guiding constituents of a desirable North-East Indian plains tea because these four constituents together accounted for about 50% of the total variations in each of briskness., quality and cash valuation, both of C. T.C. and orthodox teas. The effects of total oxygen uptake and TF on each of briskness, quality and cash valuation, both of C.T.C. and orthodox teas, were generally found to be beneficial, whereas the effects of ECG and TG of black tea were generally beneficial only beyond certain concentrations.)

6. Dutta, S. K. & Barbora, B. C. 1972. Weed control in Tea in North East India. *Planters J. & Agriculturist*, Vol. XLIX, No. 1, pp. 7.

(Abs. The names of common weeds in tea, their manual and chemical control by spraying are described in detail).

7. Kakoty, N. N. 1972. Destructive pests of tea and their control. *Plant Protect. Rept.* 2, (1), pp. 7-13.

(Abs. Diagnostic features of tea pests and control measures against them are discussed).

8. Banerjee, B. A Markovian approach to cumulative mating frequency in insects. *Ecologia* (In the press)

9. Sengupta, N. S. Biology of the tea seed bug, *Poecilocoris latus* Dall. (Pentatomidae: Hemiptera), a pest of tea seed in North East India. *Indian J. Ent.* (In the press).

Appendix-D

Summary of meteorological observations during 1971
Table : I Tocklai (Mid Assam)

Latitude : 26° 47' N Longitude : 94° 12'E Alitude : 86.6 metres a.m.s.l.

Month 1971	Daily temperature °C					Rainfall		Daily Sun-shine in hours	Daily soil temperature (Under grass)			Monthly Evaporation	
	Mean Max.	Mean min.	Mean	High-est	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Pen-man in mm
January	22.1	10.3	16.2	24.5	7.7	13.2	7	5.6	17.5	17.8	18.8	36.8	57.6
	(22.4)	(9.2)	(15.8)			(21.7)	(5)	(5.8)	(18.8)	(18.2)	(18.9)		
February	23.3	11.6	17.4	27.8	7.5	29.6	9	6.5	19.0	18.8	19.2	51.2	78.8
	(24.1)	(11.8)	(18.0)			(32.3)	(7)	(6.2)	(20.6)	(19.8)	(20.2)		
March	29.3	15.5	22.4	34.3	11.4	21.0	7	7.7	23.4	22.9	22.9	91.1	135.
	(27.5)	(15.4)	(21.4)			(82.0)	(11)	(6.6)	(24.1)	(24.1)	(23.0)		
April	28.9	19.8	24.4	33.5	15.5	84.4	13	5.9	26.4	26.3	26.0	91.1	140.
	(28.7)	(18.9)	(23.8)			(189.7)	(16)	(5.9)	(27.0)	(25.8)	(25.6)		
May	30.1	22.2	26.2	34.7	19.0	215.4	19	6.0	29.0	28.4	27.8	102.3	163.
	(29.9)	(21.7)	(25.8)			(284.7)	(20)	(5.0)	(28.6)	(27.6)	(27.6)		
June	31.9)	24.9	28.4	34.7	23.5	497.3	26	5.0	31.5	30.6	30.5	100.8	159.
	(31.5)	(24.1)	(27.8)			(324.5)	(23)	(4.4)	(30.6)	(29.6)	(29.3)		
July	32.0	24.9	28.4	35.0	23.0	329.5	22	4.8	31.3	31.0	31.0	112.3	159.
	(32.2)	(24.5)	(28.4)			(385.6)	(25)	(4.7)	(31.4)	(30.5)	(30.4)		
August	31.4	24.5	28.0	33.6	22.2	476.7	26	5.3	30.8	30.4	30.6	97.4	157.
	(32.0)	(24.5)	(28.2)			(339.0)	(23)	(5.0)	(31.4)	(30.6)	(30.4)		
September	31.8	24.5	28.2	34.0	23.0	227.8	14	5.8	30.9	30.4	30.6	97.4	140.
	(31.2)	(23.8)	(27.5)			(254.3)	(19)	(5.0)	(30.6)	(30.1)	(30.2)		
October	29.0	21.9	25.4	32.4	17.7	194.9	19	5.3	27.8	27.8	28.4	69.8	112.
	(29.3)	(20.9)	(25.1)			(116.2)	(12)	(5.6)	(28.4)	(27.9)	(28.2)		
November	25.4	14.9	20.2	29.3	9.9	75.1	6	6.3	22.6	22.8	23.7	37.5	78.
	(26.3)	(15.1)	(20.7)			(26.9)	(4)	(6.1)	(24.0)	(23.6)	(24.5)		
December	23.4	10.3	16.8	25.7	7.3	29.4	3	6.9	18.4	18.4	19.7	31.7	60.
	(23.4)	(10.6)	(17.0)			(10.1)	(3)	(5.9)	(20.0)	(19 6)	(20.6)		

Percent Relative humidity
Table : I(a) Tocklai

Hours of observations I. S. T.	Jan.	Feb.	March	Apl.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
0613	94	92	89	90	90	91	91	93	93	95	95	94
	(97)	(95)	(92)	(91)	(93)	(93)	(94)	(94)	(95)	(97)	(97)	(97)
1313	55	53	43	59	66	72	72	73	70	73	59	55
	(58)	(54)	(54)	(62)	(71)	(75)	(75)	(75)	(74)	(71)	(64)	(61)

Note : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1971
Table : 2 Silcoorie (Cachar)

Latitude : 24°50' N Longitude : 92° 48' Altitude : 39.6 metres a. m.s.l

Month 1971	Daily temperature °C					Rainfall		Daily sunshine	Daily soil temperature (Under grass)			Monthly Evaporation	
	mean max.	mean min.	mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above	in hours	Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in in mm
January	25.6	11.0	18.3	28.3	8.3	12.3	5	7.8	21.0	20.4	22.0	57.4	80.0
	(25.9)	(10.9)	(18.4)			(22.2)	(2)	(8.0)	(21.4)	(20.5)	(21.3)		
February	30.1	14.5	22.3	31.8	13.1	61.8	1	8.9	22.5	21.4	22.4	79.7	114.8
	(27.3)	(12.8)	(20.0)			(52.0)	(4)	(8.1)	(23.3)	(22.0)	(22.4)		
March	32.7	15.6	24.2	36.6	12.1	9.6	3	8.9	28.6	27.0	27.0	130.8	157.1
	(30.6)	(16.6)	(23.6)			(112.7)	(8)	(7.8)	(26.7)	(25.4)	(25.4)		
April	29.6	19.7	24.6	34.9	17.2	218.0	18	6.4	27.8	26.6	27.0	113.2	146.8
	(29.7)	(20.5)	(25.1)			(224.8)	(13)	(7.8)	(29.6)	(28.2)	(28.0)		
May	32.0	22.7	27.4	35.7	19.0	206.1	17	7.5	31.3	30.0	29.8	130.8	188.3
	(32.0)	(22.8)	(27.4)			(382.8)	(19)	(6 .5)	(30.6)	(29.4)	(29.4)		
June	32.3	24.6	28.4	36.1	23.3	478.0	27	4.1	31.8	30.7	30.7	103.5	145.6
	(31.6)	(24.5)	(28.0)			(597.6)	(24)	(4.1)	(30.6)	(29.6)	(29.6)		
July	32.2	24.7	28.4	36.1	23.3	420.0	25	3.8	31.5	30.6	30.8	92.5	145.5
	(32.1)	(25.0)	(28.6)			(541.9)	(27)	(4.5)	(31.4)	(30.4)	(30.4)		
August	31.1	24.3	27.7	35.1	22.9	487.0	29	4.0	30.6	30.0	30.2	92.9	13 .7
	(32.2)	(25.0)	(28.6)			(436.8)	(25)	(4.8)	(31.4)	(30.6)	(30.6)		
September	32.3	24.3	28.3	36.1	22.9	274.3	20	6.3	31.5	30.5	30.5	111.0	149.9
	(32.3)	(24.6)	(28.4)			(351.7)	(18)	(5.6)	(31.2)	(30.4)	(30.5)		
October	31.2	23.1	27.2	34.3	19.1	321.2	15	5.5	29.4	28.8	29.3	83.6	122.6
	(1.1)	(22.4)	(26.8)			(216.3)	(11)	(6.5)	(29.4)	(28.8)	(29.0)		
November	27.8	16.3	22.0	31.9	10.9	95.6	7	8.0	24.6	24.2	25.4	61.9	99.1
	(0.2)	(17.0)	(23.1)			(17.7)	(2)	(7.9)	(25.9)	(25.5)	(26.0)		
December	25.2	12.0	19.1	29.6	10.1	2.8	1	8.8	22.0	21.5	22.8	59.0	81.7
	(27.0)	(12.6)	(19 8)			(7.6)	(1)	(7.9)	(17.8)	(22.4)	(23.0)		

Percent Relative humidity
Table : 2(a) Silcoorie

Hours of observations I. S. T.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	99	95	92	92	92	96	96	97	96	94	98	99
	(98)	(97)	(93)	(91)	(91)	(95)	(95)	(96)	(95)	(97)	(97)	(98)
1319	14	38	32	62	64	76	73	76	72	70	61	54
	(16)	(43)	(44)	(55)	(67)	(76)	(75)	(74)	(71)	(67)	(55)	(48)

Note :— (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1971
Table : 3 Nagrakata (Dooars)

Latitude : 26°54' N Longitude : 88°55' E Altitude : 228.6 metres a.m.s.l

Month 1971	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (Under grass)			Monthly Evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 and above		Depth 5 cm	Depth 15 cm	Depth 30 cm	Open pan in mm	Penman in mm
January	23.3	10.7	17.0	26.4	7.1	6.1	3	6.9	18.7	19.4	20.3	73.3	69.6
	(23.7)	(10.3)	(17.0)			(12.8)	(2)	(8.0)	(18.0)	(18.0)	(19.4)		
February	25.5	11.9	18.7	29.6	7.0	5.4	3	7.3	20.3	20.6	20.8	102.4	93.1
	(25.6)	(13.0)	(19.3)			(20.9)	(3)	(7.7)	(20.1)	(19.7)	(20.6)		
March	30.3	16.8	23.6	34.7	11.4	5.4	2	7.7	24.5	24.5	24.2	161.8	149.8
	(29.1)	(16.3)	(22.7)			(49.4)	(6)	(7.7)	(23.8)	(23.2)	(23.6)		
April	28.4	19.2	23.8	32.5	16.4	414.1	20	5.1	24.9	24.8	24.8	112.8	134.9
	(31.3)	(20.0)	(25.6)			(117.3)	(10)	(7.3)	(27.0)	(26.2)	(26.6)		
May	29.6	21.1	25.3	33.2	19.0	263.6	16	6.3	27.6	27.0	26.8	128.0	161.2
	(31.0)	(21.7)	(26.4)			(303.3)	(20)	(6.7)	(28.5)	(27.6)	(28.0)		
June	28.6	23.8	26.2	32.4	22.0	840.1	28	3.3	28.6	28.3	28.6	86.6	125.5
	(30.4)	(23.3)	(26.8)			(893.5)	(26)	(3.8)	(28.6)	(28.0)	(28.3)		
July	30.7	23.9	27.3	34.2	22.5	974.7	28	4.0	29.4	29.0	29.2	121.6	140.6
	(30.3)	(23.8)	(27.0)			(1049.8)	(27)	(3.4)	(29.0)	(28.3)	(28.6)		
August	30.0	23.6	26.8	32.9	22.5	697.1	30	3.0	28.7	29.3	28.9	87.6	123.2
	(30.6)	(23.7)	(27.2)			(773.2)	(28)	(4.0)	(29.2)	(28.7)	(29.0)		
September	30.8	23.1	27.0	34.0	21.6	418.1	24	1.8	29.2	29.4	29.2	113.4	125.7
	(30.6)	(22.9)	(26.8)			(554.8)	(21)	(5.2)	(28.9)	(28.8)	(28.9)		
October	29.5	19.9	24.7	32.9	13.6	472.3	12	6.6	26.4	26.8	27.0	105.1	119.8
	(29.9)	(19.3)	(24.6)			(174.7)	(10)	(8.0)	(26.8)	(27.2)	(27.2)		
November	26.8	14.7	20.7	29.9	10.7	42.3	6	8.0	22.2	23.0	23.8	74.8	90.7
	(27.2)	(14.6)	(20.9)			(12.2)	(3)	(8.6)	(22.6)	(22.9)	(24.0)		
December	25.2	11.4	18.3	27.5	9.5	15.2	1	8.8	18.6	19.4	20.4	83.6	74.4
	(24.9)	(11.5)	(18.2)			(3.4)	(1)	(8.5)	(19.6)	(19.9)	(21.2)		

Percent Relative humidity
Table : 3(a) Nagrakata

Hours of observations I. S. T.	Jan.	Feb.	March	April	June	July	Aug.	Sept.	Oct.	Nov.	Nov.	Dec.
0634	90	79	67	87	87	95	96	97	99	89	86	82
	(84)	(81)	(75)	(75)	(86)	(95)	(96)	(96)	(95)	(88)	(86)	(86)
1334	50	40	36	65	70	84	81	83	78	67	54	53
	(51)	(50)	(51)	(52)	(69)	(82)	(84)	(82)	(79)	(66)	(58)	(53)

Note :— (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1971
Table : 4 Nagri Farm (Darjeeling)

Latitude : 26°55'N Longitude : 88° 12'E Altitude : 1158.2 metres a.m.s.l.

Month 1971	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass)			Monthly Evaporation	
	Mean max.	Mean min	Mean	Highest	Lowest	Monthly in mm	Day with 0.30 mm and above		Depth 5cm	Depth 15 cm	Depth 30 cm	Open pan in mm	Penman in mm
January	14.7 (15.2)	7.6 (7.8)	11.2 (11.5)	19.1	4.5	4.3 (19.5)	2 (3)	5.8 (6.4)	14.3 (13.1)	13.0 (12.5)	15.2 (13.9)	42.6	53.3
February	16.0 (16.9)	9.1 (9.6)	12.6 (13.2)	22.3	4.8	4.9 (17.4)	2 (3)	5.5 (6.1)	14.7 (14.8)	12.6 (13.7)	14.6 (14.6)	55.8	73.0
March	23.2 (20.8)	14.0 (12.8)	18.6 (16.8)	26.7	7.0	19.1 (60.8)	4 (5)	7.6 (6.7)	20.8 (18.8)	18.0 (17.2)	19.0 (17.5)	125.3	132.5
April	21.9 (23.6)	14.0 (15.9)	18.0 (19.8)	26.3	12.2	318.6 (75.0)	22 9)	3.1 (6.0)	19.6 (21.9)	17.6 (20.2)	19.1 (20.3)	69.4	100.6
May	23.0 (24.0)	16.0 (17.3)	19.5 (20.6)	26.4	14.0	223.6 (201.3)	26 (18)	4.5 (5.4)	22.2 (23.6)	19.8 (22.1)	21.7 (22.0)	64.1	127.3
June	24.4 (24.0)	18.3 (18.8)	21.4 (21.4)	27.8	17.6	581.1 (418.2)	29 (25)	2.4 (3.0)	24.4 (24.5)	22.3 (23.3)	23.5 (23.2)	60.5	105.8
July	24.7 (24.1)	18.8 (19 4)	21.8 (21.8)	27.8	17.5	664.3 (672.0)	28 (27)	2.6 (2.4)	25.4 (24.8)	22.9 (23.7)	24.0 (23.8)	69.7	115.2
August	24.3 (24.6)	18.7 (19.1)	21.5 (21.8)	27.4	17.1	396.8 (480.5)	28 (27)	2.4 (3.2)	25.2 (25.2)	22.8 (24.6)	24.0 (24.2)	53.9	104.5
September	24.8 (24.3)	18.1 (18.3)	21.4 (21.3)	27.8	16.8	233.1 (309.5)	21 (20)	3.4 (4.1)	24.6 (24.4)	22.7 (23.4)	23.9 (23.8)	60.2	100.0
October	24.1 (23.2)	16.2 (15.5)	20.2 (19.3)	25.9	13.4	201.6 (129.7)	11 (7)	5.9 (6.9)	21.7 (22.1)	20.4 (21.0)	22.0 (21.8)	74.6	102.5
November	20.5 (20.0)	12.0 (11.7)	16.2 (15.8)	24.3	9.9	15.0 (11.5)	5 (2)	(7.1) (7.0)	18.0 (18.0)	16.4 (17.3)	18.8 (18.7)	62.5	76.8
December	18.7 (17.6)	9.3 (9.3)	14.0 (13.4)	21.9	7.0	1.3 (2.7)	1 (1)	8.1 (6.9)	14.4 (14.8)	12.6 (14.1)	15.3 (15.7)	56.2	64.9

Percent Relative humidity
Table : 4(b) Nagri-Farm

Hours of observations I. S. T.	Jan.	Feb.	Marc	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0637	74 (70)	66 (70)	57 (65)	80 (67)	82 (80)	94 (92)	91 (94)	94 (94)	92 (89)	80 (76)	67 (69)	52 (70)
1337	73 (69)	61 (66)	50 (61)	75 (66)	84 (82)	88 (89)	88 (90)	86 (88)	88 (86)	79 (79)	66 (73)	57 (71)

Note :— (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.